A STRATEGIC PLAN FOR EARTHQUAKE SAFETY IN UTAH

UTAH SEISMIC SAFETY COMMISSION
January 1995

PREFACE

This document is the result of many stages of planning and review, first by the Utah Earthquake Advisory Board and its four standing committees, and then by the Utah Seismic Safety Commission (USSC). The USSC was created in July 1994 by Utah House Bill 358 and was mandated to produce this document for the 1995 Utah Legislature. A draft of the document was completed in August 1994 and sent out for public comment during September 1994. Comments were solicited from state and federal government agencies, professional societies, the Utah League of Cities and Towns, the Utah Association of Counties, interested private individuals, and all groups listed as "responsible agencies" in the document. Written comments were received, carefully considered, and incorporated as feasible into this final report.

A Strategic Plan for Earthquake Safety in Utah emphatically is only a beginning, both in detail and in action. Implementing the strategic plan will be an evolutionary process that will adjust to changing priorities, new information, and broader community involvement. Utah has already made many significant steps toward earthquake safety and preparedness, but there is a long way to go. This document identifies needs and creates a framework to coordinate efforts and monitor progress. Hopefully we can use what was learned in the January 1994 Northridge, California, earthquake and other recent seismic disasters to prepare Utah before a large earthquake strikes here.

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EXECUTIVE SUMMARY

♦ *Introduction*

The mission of the Utah Seismic Safety Commission (USSC), building on work of its predecessor, the Utah Earthquake Advisory Board (UEAB), is to develop a strategic plan for earthquake safety in order to save lives, prevent injuries, protect property and the environment, and reduce social and economic disruption from earthquakes. This document was developed through a review and planning process undertaken by the UEAB and contains a list of recommended "strategies" to reduce losses from earthquakes. The document has been completed and adopted by the Utah Seismic Safety Commission as a strategic plan for presentation to the 1995 Utah Legislature.

The main points this document attempts to make are the following:

1. There is a real and serious danger of both life-threatening and damaging earthquakes in Utah in our lifetimes.

2. We as individuals and collectively can take significant actions now to reduce the loss of life, property damage, and long-term economic impact in the future.

3. Implementing an earthquake-safety plan for Utah is a long-term process.

4. Strategies to safeguard lives and property from earthquakes must be sensitive to financial and regulatory burdens. Many actions can be taken now without great expense that will make Utah safer tomorrow.

We believe government has a fundamental responsibility to protect the health, safety, and welfare of its citizens. With respect to earthquake safety, this involves five basic actions: (1) improving our geotechnical understanding of earthquakes and earthquake hazards, (2) improving development and construction practices, (3) educating the public, (4) disaster-response planning, and (5) post-earthquake recovery planning. These actions and the recommended strategies in this document are consistent with Governor Leavitt's Key Objectives and with the Utah Legislature's strategic plan, *Utah Tomorrow*. The individual strategies have been placed in a format consistent with state planning guidelines.

Efforts to promote public policy for earthquake safety in Utah began nearly two decades ago with the Utah Seismic Safety Advisory Council (1977-1981), followed by the Earthquake Task Force of the Utah Advisory Council on Intergovernmental Affairs (1989-1991) and later the UEAB (1991-1994). Responsibility has now passed to the USSC.

♦ *The Earthquake Threat in Utah*

Utah has experienced damaging earthquakes in the past, and geologic evidence indicates that earthquakes larger than any experienced locally in historical time are likely in the future. Large earthquakes are possible anywhere in Utah, but they are most likely in a "seismic belt" about 100 miles wide extending north-south along the Wasatch Front and through Richfield to Cedar City and St. George.

Earthquakes produce a variety of geologic hazards that threaten life and property. These hazards include ground shaking, surface fault rupture, regional subsidence, liquefaction and related ground failure, landslides, rock falls, and various types of flooding. Earthquake hazards are greatest in the Wasatch Front area because of the greater earthquake probability and because of extensive areas where geologic conditions pose the potential for damaging, earthquake-induced effects. The probability of large earthquakes appears to be slightly lower in southwestern Utah, and geologic conditions there are not as prone to aggravate earthquake effects. In general, earthquake probabilities and hazards are lower in eastern and western Utah outside the main seismic belt.

We must prepare for earthquakes because: (1) Utah is a seismically active region, (2) our population is concentrated in the areas of greatest hazard, and (3) many of our older buildings and lifelines have low earthquake resistance. We have been lucky so far to experience only moderate-sized earthquakes, of which the majority have originated in areas of low population; we cannot expect this luck to last.

♦ *Strategies for Earthquake Safety*

The following pages list the main objectives and strategies for earthquake safety. The list of strategies, which is not in order of priority, is not intended to be exhaustive. Work will continue to develop consensus and to set priorities for action. Also listed in the following pages are the planned outputs (for example, products, plans, and assessments) and desired outcomes, in terms of increased earthquake safety, for each strategy.

Summary of Strategies

Objective 1: Increase earthquake awareness and education.		
Strategy	**Output**	**Outcome**
1.1 Inform citizens about earthquake hazards and risks.	Information and training targeted to meet individual or collective needs.	All citizens are better able to prepare for and respond to an earthquake.
1.2 Incorporate earthquake education in school curricula.	A multi-level curriculum for earthquake education in all public schools.	All students are provided with earthquake science and safety training as a part of their regular education.
1.3 Disclose geologic hazards in real-estate transactions.	Homebuyers are made aware of geologic hazards at a property prior to purchase.	Homebuyers are more informed in their decisions.

Objective 2: Improve emergency response and recovery.		
Strategy	**Output**	**Outcome**
2.1 Establish community emergency response teams (CERTs) statewide.	Trained volunteer community emergency response teams exist statewide.	Reduce life, property, and environmental loss by providing more immediate response in a disaster.
2.2 Develop effective exercise and training programs for hospitals.	All hospital staff are trained for earthquake emergency response including implementing a standardized triage system.	Hospitals are prepared for earthquake response.
2.3 Enhance communication capabilities for emergency responders.	Develop a communication system that will allow for the use of new technologies and provide the capability of expansion during peak disaster use.	Emergency response capability will be enhanced because the new communication system will allow for the interoperability of agencies to meet the requirements of multi-agency response.
2.4 Enhance the integrated emergency management system statewide.	An intergrated emergency management system at all levels of government and the private sector to protect life, health, property, and the environment.	All jurisdictions and agencies can more fully utilize their resources to respond to any type of a disaster, including earthquakes.

Objective 3: Improve the seismic safety of buildings and infrastrucure.		
Strategy	**Output**	**Outcome**
3.1 Improve plan review procedures on new construction to ensure that buildings are being designed in accordance with current seismic code requirements.	Competent plan reviews are completed for new construction.	Help ensure that new buildings are being designed safely by competent professionals to withstand seismic forces.

3.2 Enforce the state amendment to the Uniform Building Code which requires building owners to install roof anchors and parapet bracing when reroofing their buildings.	Copies of the amendment are distributed to building officials, architects, and engineers through the media and professional societies, and education programs are conducted.	A gradual decrease in the seismic hazard posed by existing unreinforced masonry buildings.
3.3 Improve the post-earthquake operational status of essential service buildings.	All essential government services buildings are identified. Buildings constructed before 1976 are retrofitted or relocated as needed, to meet standards that will allow them to remain operational after an earthquake.	The ability to provide unimpeded disaster relief services.
3.4 Reduce structural hazards of government-owned buildings.	Government-owned buildings structurally modified to better withstand earthquakes.	A safer environment to conduct government business.
3.5 Mitigate nonstructural hazards in government-owned and -leased buildings.	Assess hazards in government-owned buildings and upgrade as necessary.	A safer and operational working environment for government agencies following an earthquake.
3.6 Improve safety of older public school buildings.	Identify and reduce structural and non-structural seismic hazards in all pre-1976 public school facilities.	Safer facilities for students and teachers, as well as buildings usable in an emergency.
3.7 Improve safety and operational ability of older hospital buildings.	Assess earthquake vulnerability of all hospitals and upgrade the structures to better survive an earthquake.	Safe structures that will provide a more secure environment for patients and staff and improved ability to survive an earthquake and provide disaster relief.
3.8 Improve safety of older high-occupancy buildings (250 persons or more) to be structurally competent to withstand moderate to large earthquakes.	Assess seismic vulnerability of all older high-occupancy structures and retrofit or disclose building condition upon resale.	Prevent collapse in the event of an earthquake, thus reducing life loss, property loss, potential secondary effects, and reconstruction costs.
3.9 Improve the seismic safety of older homes.	Create and distribute maps of seismic-hazard areas and upgrade information packets, procedural manuals, standards, and requirements to all affected home owners, all real-estate agents, building contractors, and lending institutions. Establish funding sources and incentives to encourage seismic-safety retrofitting.	Improved safety and lower repair costs in the event of an earthquake.
3.10 Improve safety of mobile homes.	Seismically brace all new mobile homes; retrofit inadequately braced existing mobile homes at time of resale. Create and implement incentive packages to encourage mobile home owners to retrofit existing installations.	Increased safety for occupants, reduced amounts of utility rupture and associated hazards and repair costs.

3.11 Prevent loss of historic buildings.	Vulnerability assessments and mitigation completed on buildings on the National Historic Register.	The preservation of historic buildings and their associated heritage in the event of an earthquake.
3.12 Improve lifeline survivability in the event of an earthquake.	Assess and mitigate earthquake hazards on all lifelines.	Functional or easily/rapidly repairable lifelines after a earthquake.
3.13 Improve earthquake performance of water and waste-water systems.	Establish appropriate and practical uniform safety and emergency-response plans for all water and waste-water systems.	Improved safety, performance, and reliability of water and waste-water systems.

Objective 4: Improve essential geoscience information.

Strategy	Output	Outcome
4.1 Reduce earthquake losses by mapping and identifying geologic hazards.	Hazard maps for all earthquake-prone urban areas.	Development and management are safer, more reasoned, and more cost-effective.
4.2 Perform geologic-hazards investigations for critical public facilities.	Geologic-hazards investigations are performed for all new critical public facilities.	Critical facilities will not be sited in hazardous areas and, in the event of a natural disaster, facilities that are needed for emergency response will remain intact.
4.3 Make land use compatible, through local government ordinances, with known hazards.	Local governments are encouraged or required to adopt geologic-hazards ordinances as needed.	Land use is safer and consistent with identified geologic hazards.
4.4 Ensure design professionals and building officials are kept current on relevant geoscience information.	Periodic meetings of geoscientists and engineers to discuss implications of geoscience information to building safety.	Up-to-date, reliable geoscience information is used to guide the safe and economical earthquake-resistant design of new buildings.
4.5 Determine appropriate seismic criteria and procedures for evaluating performance of existing dams.	Guidelines for seismic safety assessments of existing dams.	Uniform, state-of-the-art assessments of seismic safety of dams.
4.6 Reduce earthquake-induced liquefaction risk to highway structures.	Identify all hazardous bridges; generate a plan to reduce hazards.	Highway bridges are safer in the event of earthquake-induced liquefaction.
4.7 Determine appropriate seismic design coefficients for highway bridges.	Calculate and incorporate new seismic design coefficients in design work for new bridges associated with the widening of I-15.	(1) Ensure that the best available information is used for the safe and economical design of the new bridges. (2) Prevent the need for retrofit of the bridges in the near future. (3) Reduce bridge damage in an earthquake.

4.8 Develop incrementally a strong-motion program.	Deploy at least 108 accelerographs in the seismic regions of the state to record strong ground shaking.	The hazard of strong ground shaking from local earthquakes is better quantified so it can be correctly incorporated into safe, cost-effective design of buildings and other structures. Key information can also be rapidly available for crisis management.
4.9 Develop a statewide, real-time earthquake monitoring system.	(1) Increased number of seismically vulnerable counties and cities in Utah for which continuous and accurate instrumental earthquake data are available. (2) Rapid emergency alert, within minutes after the occurrence of an earthquake in the Utah region, to state-agency officials, emergency managers, and the general public.	Collect and distribute data needed: (1) for more cost-effective earthquake engineering, (2) for more rapid and effective emergency response, (3) to reliably quantify earthquake dangers, and (4) to improve scientific understanding of local earthquake behavior, in order to better mitigate effects.
4.10 Monitor faults using Global Positioning System (GPS) measurements.	Regular monitoring of a network of GPS benchmarks.	Strain buildup and ground deformation associated with faults are understood on a very detailed level, allowing more accurate estimation of the likelihood of large earthquakes and accompanying hazards.

Objective 5: Assess earthquake risk.

Strategy	Output	Outcome
5.1 Update estimates of direct losses expectable from earthquakes.	Comprehensive studies to estimate the potential loss of life, number of injuries, and damage to structures and lifelines from earthquakes of various magnitudes and locations.	Earthquakes are placed in a proper policy perspective based on credible projections of losses and societal impacts; emergency planning is improved; and long-term hazard-reduction activities are prioritized.
5.2 Evaluate the indirect losses associated with earthquakes.	A study assessing the indirect economic losses from earthquakes including: wage and job loss, rebuilding cost, impacts on insurance and financial institutions, and costs of business interruption and failure.	Identification of indirect economic impacts, resulting in increased preparedness, more rapid recovery, and wise resource allocation.
5.3 Conduct lifeline collocation vulnerability studies.	All lifeline collocation sites in UBC seismic zone 3 are identified; a plan is developed for each one.	During an earthquake emergency, damaged lifelines in one area will not cripple each other.

INTRODUCTION

♦ *Mission*

The impacts of earthquakes are well known. This knowledge has come at great cost in lives and property. We must take advantage of this knowledge to adopt policies and take actions to save lives and prevent injuries, protect property and the environment, and reduce social and economic disruption from earthquakes in Utah. With the ultimate goal of making Utah a safer place to live, the mission of the Utah Seismic Safety Commission (USSC), as for its predecessor, the Utah Earthquake Advisory Board (UEAB), is to function as a medium for state and local governments, the private sector, and the public to advance earthquake-related issues by developing, researching, and recommending seismic policies and approaches aimed at reducing Utah's earthquake hazards and managing Utah's earthquake risk. The USSC was given the charge to:

- ❑ Review earthquake-related hazards and risks in Utah.
- ❑ Prepare recommendations to identify and mitigate these hazards and risks.
- ❑ Prioritize recommendations for adoption as policy or loss-reduction strategies.
- ❑ Act as a source of information for earthquake safety and promote earthquake loss-reduction measures.
- ❑ Prepare a strategic seismic safety planning document for the 1995 General Legislative session.
- ❑ Update the strategic planning document and other supporting studies or reports.

To achieve part of its mission, the USSC has completed this document prepared in draft form by the UEAB. The main points that the USSC and this document are attempting to make are the following:

1. There is a real and serious danger of both life-threatening and damaging earthquakes in Utah in our lifetimes.
2. We as individuals and collectively can take significant actions to reduce the loss of life, property damage, and long-term economic impact in the future.
3. Implementing an earthquake-safety plan for Utah is a long-term process.
4. Strategies to safeguard lives and property from earthquakes must be sensitive to financial and regulatory burdens. Many actions can be taken now, without great expense that will make Utah safer tomorrow.

♦ *Government Responsibility*

We believe government has a fundamental responsibility to protect the health, safety, and welfare of its citizens. The government's role in improving earthquake safety is to foster, encourage, and, where necessary, require individual and collective action to deal responsibly with the earthquake threat. Reducing our vulnerability to earthquakes requires five types of actions: (1) improving our geotechnical understanding of earthquakes and earthquake hazards, (2) improving development and construction practices, (3) educating the public concerning earthquake hazards and how to respond during a hazardous event, (4) disaster-response planning, and (5) post-earthquake recovery planning. These actions necessarily involve an understanding of what will be effective in reducing risk and an appreciation of the willingness and ability of the people involved to take action.

Government, academic, and private-sector scientists and engineers must work together to understand the earthquake threat to help determine which loss-reduction strategies are appropriate and cost-effective. Improvement of development and construction practices is primarily the responsibility of state, county, and municipal government agencies through adoption and enforcement of building codes, subdivision zoning, and retrofit ordinances. Public education is an ongoing process requiring coordination and cooperation among local school districts, state agencies, and universities to reach all citizens. Government agencies must develop disaster-response plans to identify: (1) the types of decisions that are likely to be needed when the expected earthquake event occurs, (2) who will make the decisions, and (3) how the decisions will be transmitted to the public and emergency-response personnel for implementation. Recovery plans are also needed to anticipate and meet the needs of communities as the post-earthquake recovery period unfolds over a period that may be as long as 5 to 20 years. These plans will help ensure a quick return to cultural and economic viability following an earthquake.

♦ *Governor's Objectives*

For effective strategic planning, within the realm of state government, plans should be developed in harmony with a statewide vision. The cornerstone of Governor Leavitt's planning agenda is a set of overall policy goals known as the "**Five Key Objectives**." These objectives address issues critical to elevating Utah State Government to a new level of performance. They are:

1. Providing a world-class education.
2. Creating quality jobs and business climate.
3. Improving government.
4. Enhancing the quality of life for all Utahns.
5. Fostering self-reliance.

The strategies proposed in this document are consistent with Governor Leavitt's Key Objectives. They are also consistent with—and indeed many are already part of—the Utah State Legislature's strategic plan, *Utah Tomorrow.*

First, dealing with Utah's earthquake threat relies on earthquake science and engineering, much of it within Utah's system of higher education, involving the development and application of modern technologies in a world-class way.

Second, a healthy business climate in Utah depends on essential infrastructure—including the means to deal with a real and serious earthquake threat. As emphasized by a 1989 blue-ribbon panel (convened to review earthquake instrumentation in Utah), "Potential earnings will come...from increased willingness on the part of risk-conscious investors to fund large projects in Utah once the earthquake threat and the means to cope with it are better understood." A decision by state policy-makers to implement a strategic plan for dealing with Utah's earthquake dangers will favorably impress sophisticated risk managers, who increasingly will be involved, for example, in the siting of new industries or in decisions to fund private economic development.

Third, this plan provides a means to improve government by increasing awareness of the earthquake threat and promoting responsible actions to reduce risks. The threat is far-reaching, requiring a coordinated effort by all levels of government - federal, state, and local.

Fourth, the strategies proposed in this plan are fundamental for ensuring quality of life in the form of safety for all Utahns in their homes, schools, workplaces, and neighborhoods.

Fifth, self-reliance involves education, which inherently involves information and public instruction, to deal with the complexities of modern life. One complexity is that earthquakes pose the greatest natural threat to life and property in Utah. These strategies are intended to help Utahns become progressively self-reliant in avoiding major loss of life and property in earthquakes.

♦ *History of Seismic Advisory Committees in Utah*

In 1976, the United States Geological Survey (USGS) published a study of the likelihood of and projected losses from major earthquakes in Utah. This study reported that a moderate to large earthquake was likely to strike the Salt Lake City area within the next 100 years with serious repercussions. The USGS considered "seismicity, geological history, population density, and distribution and physical status of structural and lifeline installations throughout the region." The USGS report appeared in the aftermath of a magnitude 6.0 earthquake in March 1975 in Pocatello Valley on the Idaho-Utah border. This earthquake was felt throughout the Salt Lake Valley and the northern part of Utah and damaged several buildings in Salt Lake County. The combined effect of the 1975 earthquake and the 1976 USGS report was to awaken political support for earthquake action among public officials representing Utah's urban areas.

Utah Seismic Safety Advisory Council, 1977-1981

State Representative Genevieve Atwood sponsored a bill in the 1977 Utah Legislature to create an earthquake advisory council to attend to seismic safety issues. The Utah Seismic Safety Advisory Council (USSAC) (see appendix) was created and became the first successful effort to shape public policy for reducing earthquake risk in Utah. The USSAC mission was to "provide recommendations for a consistent policy framework for seismic safety in Utah, to recommend programs to reduce earthquake hazards, and suggest goals and priorities..." Their charge was to recommend a consistent and comprehensive public policy plan for earthquake risk reduction in Utah. Even though USSAC products were highly commended, no agency or group was given responsibility to follow through on the recommendations. Very few of the recommendations were implemented and none of the suggested legislation became law.

The USSAC, nonetheless, made a significant difference in earthquake risk reduction in Utah by:

- Linking several of the isolated scientists and earthquake-safety activists into a network.
- Focusing attention on earthquake hazards.
- Writing a series of reports that documented the status quo of earthquake preparedness and provided a framework for action.
- Bringing together local leaders with national experts.
- Providing visibility for all individuals and agencies who wanted to contribute to earthquake-hazard reduction.
- Providing an umbrella of political legitimacy to engineering, political, scientific, and other professional groups who lobbied their membership for increased acceptance of state-of-the-art techniques.
- Providing a supportive network that lasted beyond the lifetime of the organizations.

The USSAC conducted or commissioned numerous studies, sponsored meetings, issued reports, and in other similar ways dealt with the earthquake threat in Utah.

1981-1991

After the USSAC was dissolved in 1981 under the "sunset" provision of its enacting law, the role of coordinating a state earthquake program effectively passed to informal cooperative efforts among the Utah Geological Survey (UGS), the Utah Division of Comprehensive Emergency Management (CEM), and the University of Utah Seismograph Stations (UUSS). Federal attention to Utah's earthquake threat greatly increased from 1983 to 1988 as part of a special five-year focus on earthquake hazards and risk in the Wasatch Front region by the U.S. Geological Survey under the National Earthquake Hazards Reduction Program. As a result of the five-year program, earth scientists and engineers amassed a large body of technical information and reached fundamental agreement about the seriousness, extent, and nature of Utah's earthquake dangers. Despite a greatly-heightened public awareness of Utah's earthquake threat, numerous attempts to motivate state governmental action on earthquake issues were mostly unsuccessful. From 1989-1991, most of these efforts were coordinated through the Earthquake Task Force of the Utah Advisory Council on Intergovernmental Relations (UACIR) (see appendix). The UACIR's activities culminated in late 1990 when the Earthquake Task Force presented a list of critical needs for 1991 legislation to improve earthquake safety. As a result, six bills and one resolution which in some way dealt with earthquake safety were introduced into the 1991 Legislature. All failed (through inaction rather than defeat), but the debate over the bills further increased awareness and gained support from many key legislators.

Utah Earthquake Advisory Board (UEAB), 1991-1994

In 1991, the Utah Earthquake Advisory Board (UEAB) was formed at the instigation of state officials and was funded through CEM by a supplemental grant from the Federal Emergency Management Agency (FEMA). Approval was gained to create the Board as an advisory group within the executive branch of state government, placing it under the Governor's Disaster Emergency Advisory Council. Under the terms of the Board's charter, Board members were chosen from leaders in their fields of expertise such as seismology, geology, structural engineering, geotechnical engineering, architecture, public policy, and emergency management. The makeup of the Board included members representing state agencies, local government, professional organizations, and the private sector (see appendix).

The mission of the UEAB was to advance earthquake-related issues by developing, researching, and recommending seismic policies and providing a long-term strategic planning document to reduce Utah's earthquake hazards through managing the state's earthquake risk. With completion of the draft of this document, the UEAB achieved a major part of its mission and turned its responsibilities over to the Utah Seismic Safety Commission, effective July 1, 1994.

Utah Seismic Safety Commission, 1994 to present

State Representative Kim Burningham introduced legislation in the 1994 Utah Legislature to establish a commission to study and advance earthquake safety in Utah. HB 358 passed, establishing the Utah Seismic Safety Commission (USSC) and designating the Utah Division of Comprehensive Emergency Management and the Utah Geological Survey to provide staff support. The make-up of the USSC is similar to the UEAB but includes representatives from the Utah Senate and House of Representatives (see appendix). The USSC was charged with preparing a strategic planning document for the 1995 Utah Legislature. With completion of this document, the duties of the USSC shift to facilitating implementation of the strategic plan and keeping it up-to-date.

♦ *Acknowlegements*

The USSC gratefully acknowledges the help of the UEAB and its standing committees, identified in the appendix, and UEAB staff support by: Bob Carey, Jim Tingey, Caryn Johnson, Nancy Barr, John Rokich, Jeanne Andersen, and Judy Watanabe of CEM; Gary Christenson, Noah Snyder, and Janine Jarva of the UGS; and Sue Nava of the UUSS. These staff, along with UGS staff Barry Solomon and Don Adams, helped prepare this report.

THE EARTHQUAKE THREAT IN UTAH

Earthquakes can cause injury and death, major economic loss, and social disruption. They occur with no warning. A recent, disturbing example was the magnitude 6.7 Northridge, California, earthquake of January 17, 1994, in the densely populated Los Angeles metropolitan area. The earthquake killed 61 people, injured 7,300, made 21,000 homes and apartments uninhabitable, and caused an estimated $20 billion in damage.

Utah has also experienced damaging earthquakes and has the potential for earthquakes larger than the recent Northridge shock. Although no large earthquake has occurred in Utah since settlement in 1847, geologic studies indicate that earthquakes of magnitude 7.0 to 7.5 have occurred repeatedly in Utah in prehistoric time. Along the populous Wasatch Front such earthquakes occur on the Wasatch fault, on average, once every 400 years. Some experts believe that the last occurred about 400 years ago.

♦ *What Is An Earthquake?*

An earthquake is the abrupt rapid shaking of the earth caused by sudden slippage of rocks deep beneath the earth's surface. The rocks slip when they can no longer withstand accumulated forces. The zone of weakness along which the rocks slip is called a fault. Shaking is caused by seismic waves travelling outward from the fault break (figure 1).

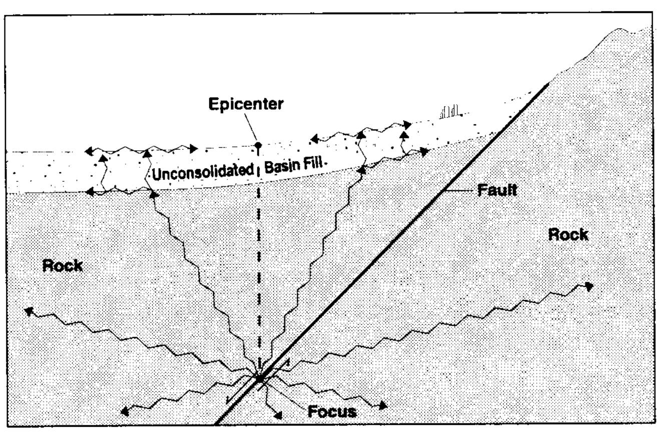

Figure 1. Generation of seismic waves by fault rupture in an earthquake as shown in this cut-away cross section. The focus is the place on the fault where the rupture begins. The point on the surface directly above the focus in the epicenter.

The most commonly used way to measure earthquake size has been the Richter scale, which measures the magnitude of earthquakes based on the amount of ground shaking recorded on a seismograph. The scale has no upper or lower bounds. Each 1-unit increase of the scale represents a 10-fold increase in the amplitude of ground displacement at any site. For example, a magnitude 6 earthquake causes 10 times greater ground displacement at the same distance than does a magnitude 5 earthquake. More importantly, each 1-unit increase represents a 30-fold increase in energy release. Thus a magnitude 6 earthquake is 30 times more powerful than a magnitude 5 earthquake. A magnitude 7 earthquake is nearly 1000 times more powerful than a magnitude 5 earthquake. An earthquake must generally be at least magnitude 2 to be felt by people, and about magnitude 5.5 before significant damage occurs. Seismologists are now using "moment magnitudes" to measure earthquakes, which extends the original Richter magnitudes to greater distances and to larger earthquakes.

♦ *Where Will Earthquakes Occur?*

Earthquakes can occur anywhere in Utah...

Hundreds of small earthquakes are recorded each year in the Utah region (figure 2.) Moderate, potentially damaging earthquakes (magnitude 5.5 to 6.5) occur every several years on average. An earthquake of magnitude 5.8 occurred near St. George on September 2, 1992. The most damaging effect of that shock was a destructive landslide in the town of Springdale, about 28 miles from the earthquake epicenter (figure 3.) Larger earthquakes occur less frequently than smaller earthquakes, but the potential for large earthquakes (magnitude 6.5 to 7.5) exists over much of Utah. Such an earthquake in the Salt Lake City area could cause up to $8.5 billion in damage to private buildings and homes alone, not including damage to other kinds of structures and facilities, and other indirect financial losses. Estimates of potential life-loss and injury made in 1976, now out of date and probably low, indicate that under the worst conditions (but assuming no dam failures), 2,300 people could die and 9,000 suffer injuries requiring medical treatment. As many as 30,000 people could be homeless and require temporary shelter.

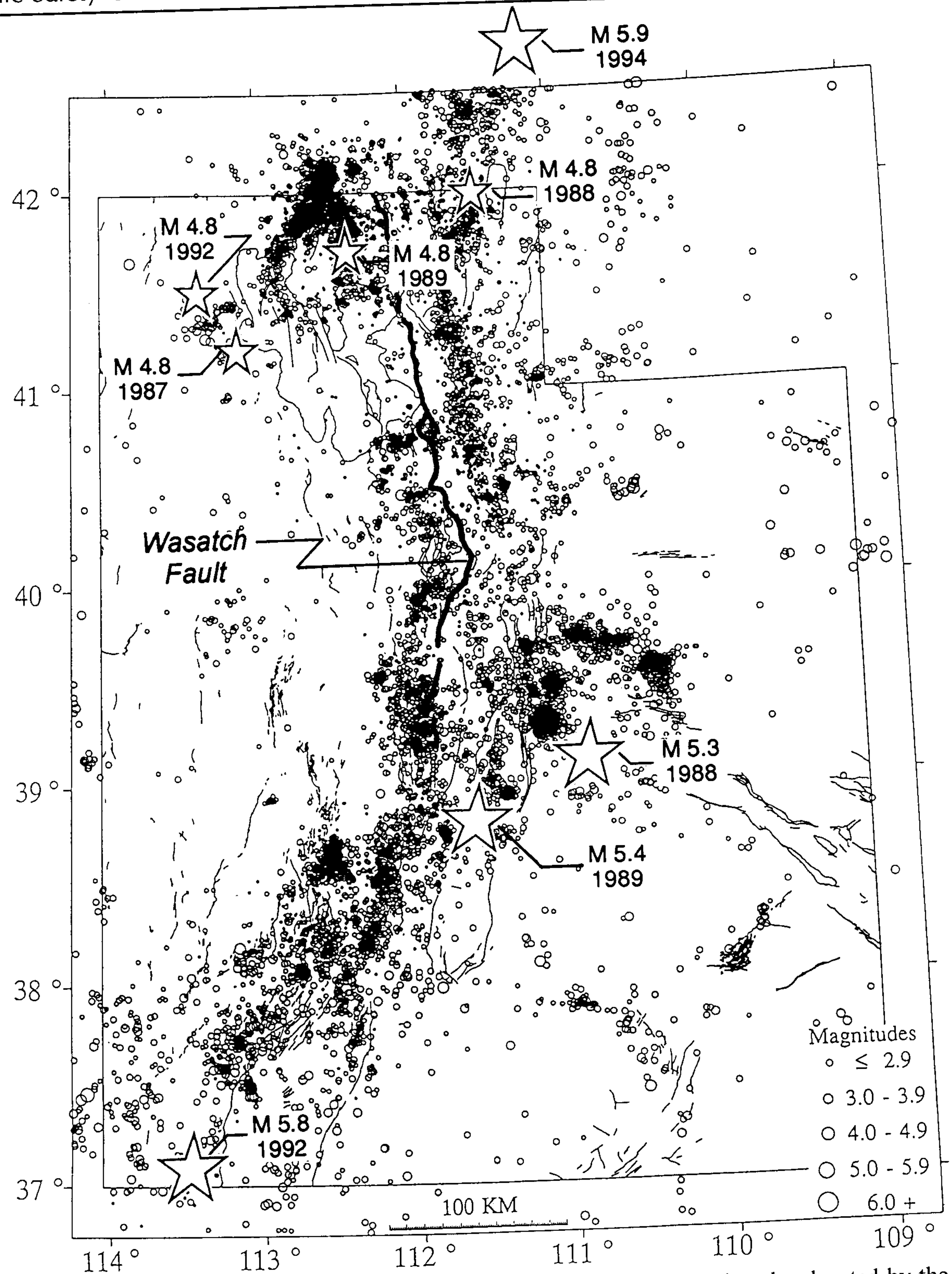

Figure 2. Map of Utah region showing the epicenters of more than 16,000 earthquakes located by the University of Utah Seismograph Stations from 1962 though 1993. Earthquakes of magnitude 4.8 and larger since 1987 shown as stars. The base map showing geologically young faults was compiled by the Utah Geological Survey.

Figure 3. House destroyed by landsliding in Springdale triggered by the magnitude 5.8 St. George earthquake of September 2, 1992. Photo by Bill D. Black, Utah Geological Survey.

...but there is a greater potential in certain areas.

The Intermountain Seismic Belt, which passes through Utah, is a broad zone more than a hundred miles wide where the frequency of earthquakes and the potential for moderate to large earthquakes is greatest. In Utah, the seismic belt passes through the north-central part of the state along the Wasatch Front and then turns southwestward through Richfield and Cedar City (figure 4.) Utah's part of the seismic belt has historically been characterized by small to moderate earthquakes, but there is clear geologic evidence of large prehistoric earthquakes in the magnitude 7 range. The earthquake probability is lower both east and west of the main seismic belt. These areas are characterized by less frequent earthquakes of all magnitudes, but they are not earthquake free.

♦ Geologic Hazards Caused By Earthquakes

Earthquakes cause a wide variety of life-threatening and potentially damaging geologic hazards in Utah. The principal earthquake hazards are ground shaking, surface fault rupture, regional subsidence, liquefaction and related ground failure, slope failure, and various types of flooding (table 1). Ground shaking affects large areas and, for a given earthquake, is generally strongest near the epicenter. In the 1994 Northridge, California, earthquake ground shaking was responsible for 98 percent of the estimated $5.9 billion in direct damages. Surface fault rupture usually occurs only in earthquakes of about magnitude 6.5 and larger. This ground rupture may

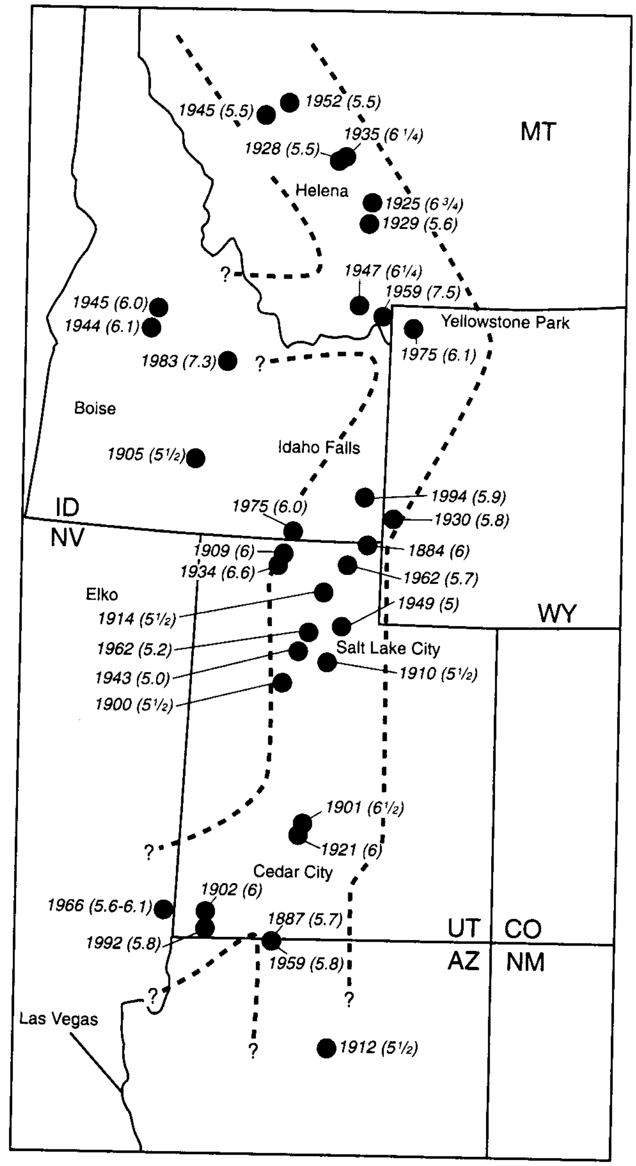

Figure 4. The Intermountain Seismic Belt (area between dashed lines) and the epicenters of historical earthquakes of magnitude 5 and greater (large dots). Year and magnitude are labeled for each earthquake. Modified from Arabasz, W.J., Pechmann, J.C., and Brown, E.D., 1992, Observational seismology and the evaluation of earthquake hazards and risk in the Wasatch Front area, *in* Gori, P.L., and Hays, W.W., editors, Assessment of regional earthquake hazards and risk along the Wastch Front, Utah: U.S. Geological Survey Professional Paper 1500-D, p. D6.

Table 1. Principal earthquake hazards, expected effects and hazard-reduction techniques.

Hazard	Effects	Hazard-Reduction Techniques
Ground Shaking	Damage or collapse of structures	Make structures seismically resistant, secure heavy objects
Surface Fault Rupture	Tilting and ground displacement	Set structures back from fault
Regional Subsidence	Ground tilting; flooding and loss of head in gravity-flow structures	Create buffer zones, build dikes, restrict basements, design tolerance for tilting
Liquefaction	Differential settlement, ground cracking, subsidence, downslope movement of earth material	Treat soil, design structural solutions
Rock Fall	Damage due to impact	Avoid hazard, remove or stabilize rock, protect structures
Landslides	Damage to structures, loss of foundation support	Avoid hazard, remove material, stabilize slopes
Seiches	Inundation, drowning, erosion	Avoid hazard, flood-proof and/or strengthen structures, elevate buildings

affect a zone many hundreds of feet wide along the surface trace of the fault that caused the earthquake. Regional subsidence and tilting of the downdropped block during a large surface-faulting earthquake extends miles from the fault, affecting a much larger area than surface faulting. Liquefaction (the temporary transformation of a cohesionless soil into a fluid mass accompanying earthquake ground shaking) is expected in areas of shallow ground water and sandy soils such as in the centers of basins and along streams. Liquefaction can result in various types of ground failure. Rock falls are the most common type of slope failure during earthquakes, but failures of many types may be expected in any hilly or mountainous area where earthquakes occur. Earthquakes may cause changes in water levels in wells and other permanent changes in hydrologic conditions. Flooding may result from water-line or canal breaks, stream diversions, increased ground-water discharge, seiches (waves on the surface of water in a lake, commonly initiated by an earthquake), and failures of dikes and dams. Ground subsidence on the valley side of the Wasatch fault could shift the shoreline of Great Salt Lake or Utah Lake eastward, resulting in inundation of neighboring areas.

♦ *In the Wasatch Front region*

Along the main seismic belt in Utah, earthquake hazards are greatest along the Wasatch Front because: (1) the Wasatch fault, which bounds the west edge of the Wasatch Range, has been the most frequent source of large earthquakes in Utah, (2) deep valley-basins filled with soft soils amplify ground shaking, (3) extensive areas are underlain by shallow ground water and liquefiable soils, and (4) Great Salt Lake, Utah Lake, and many reservoirs increase flood hazards associated with earthquakes. The largest historical earthquake in Utah was a magnitude 6.6 shock in 1934 that originated in Hansel

Valley, north of Great Salt Lake. The most damaging earthquake in Utah's history also occurred in the general Wasatch Front region -- a magnitude 5.7 shock near Richmond, Cache Valley, in 1962 (figure 5.)

♦ *In southern Utah*

Historical earthquake activity has been relatively high along the Intermountain Seismic Belt in southern Utah. But geologic evidence for recurrent, large surface-faulting earthquakes in southwestern Utah during the past 30,000 years is not as strong as in north-central Utah, where the Wasatch fault and other faults appear to be more active than faults to the south. The second largest historical earthquake in Utah was along the main seismic belt in southern Utah -- the 1901 earthquake near Richfield of estimated magnitude 6.5. One of the most prominent faults in southern Utah, the Hurricane fault, was the probable source of the 1992 St. George earthquake.

Shallow ground water is present in valley bottoms in southern Utah, but much less extensively than in northern Utah and thus the liquefaction hazard is lower. Areas of thick basin fill and soft soils are also less common in southern Utah, and therefore hazards due to amplified ground shaking are less. Because southern Utah has fewer large surface-water impoundments and natural lakes, the danger of earthquake-induced flooding is lower.

Figure 5. House damaged in Richmond during the 1962 earthquake, magnitude 5.7, the most damaging earthquake in Utah's history. Photo by Ariel D. Benson, Richmond, Utah.

♦ *In eastern Utah*

In eastern Utah, east of the main seismic belt, the earthquake probability and hazard is relatively low, but moderate-sized, potentially damaging earthquakes can occur. The largest historical earthquake in this region was the 1988 San Rafael Swell earthquake of magnitude 5.3. In Carbon and Emery Counties, extensive mining-induced seismicity results from stress redistribution caused by underground coal mining, posing a danger chiefly to mine operations. Shallow ground water is uncommon in eastern Utah, found chiefly in stream bottoms, so liquefaction is a minor hazard. Bedrock is exposed or shallow over much of the area so amplified ground shaking is unlikely, although seismic waves will travel farther and dissipate less quickly than in western Utah. Rock falls may be the most significant hazard in eastern Utah because they can be locally generated by earthquakes as small as magnitude 4, and many potentially unstable cliffs are present in the area.

♦ *In western Utah*

Earthquake hazards are also relatively low in western Utah west of the main seismic belt. However, amplified ground shaking is a hazard in valleys with deep sediments, liquefaction hazards are present in the northern valleys, and surface-faulting hazards are present along range-front faults. Slope-failure hazards are present but not extensive in the various mountain ranges, but these hazards increase to the east along the western fringe of the main seismic belt.

♦ *Why We Should Prepare For A Major Earthquake*

- ❑ Utah is a seismically active region.
- ❑ Utah's population is concentrated in the area of greatest earthquake hazard.
- ❑ Utah's older buildings and lifelines have low earthquake resistance.

There is a critical need for hazard-reduction measures, including risk identification and proper seismic-structural design and construction of buildings. Education, awareness, and preparedness are all necessary and important for Utah's residents.

STRATEGIES FOR EARTHQUAKE SAFETY

The following section lists the individual actions (strategies) that the USSC considers important to improve earthquake safety in Utah. It is not a comprehensive list and is not in order of priority. The strategies are divided into five categories to address the USSC's five key objectives:

1. Increase earthquake awareness and education.
2. Improve emergency response and recovery.
3. Improve the seismic safety of buildings and infrastructure.
4. Improve essential geoscience information.
5. Assess earthquake risk.

The first four categories correspond to topics assigned to the UEAB standing committees, and the corresponding strategies chiefly represent the work of those committees. Strategies in the fifth category (risk assessment) represent work that necessarily involves interdisciplinary input.

For each strategy, specific outputs are listed which can be measured to evaluate performance of the responsible parties in implementing the strategy. Also, the projected outcome is listed so that the ultimate goal of the strategy is known and success can be measured in light of this desired outcome. Background material explaining the need for the strategy is included, together with a brief discussion of ways to implement the strategy, a list of those responsible agencies (meaning those entities either having statutory responsibility or likely to take a leading role), and an estimate of resources needed. The latter are rough estimates which will be refined once the strategy is being considered for implementation. The list of strategies is meant to be a "living" list which can either be expanded as new actions are identified, or reduced as strategies are implemented and outcomes are achieved.

Objective 1:

Increase earthquake awareness and education.

STRATEGY: Inform citizens about earthquake hazards and risks.

OUTPUT: Information and training targeted to meet individual or collective needs.

OUTCOME: All citizens are better able to prepare for and respond to an earthquake.

Background

Different elements of Utah society have different needs for information and training to deal with mitigating and responding to the earthquake threat. There exists significant demand for earthquake education materials and services which should be appropriate, readily available, and user-friendly.

Implementation

Programs would be targeted to each of the following population segments with the corresponding products:

1. General public – A free Earthquake Awareness Guide of earthquake services and materials widely distributed.
2. School teachers – Science and safety instructional materials.
3. Businesses – Guides and training for earthquake preparedness in the workplace for managers and employees, techniques to reduce losses and resume operations quickly after a disaster.
4. Architects, engineers, contractors – coordination of materials and training through professional associations and licensing agencies.
5. Local government – awareness program of materials, services, and information on laws, procedures, rules, and standards.

Responsible Agencies

Utah Division of Comprehensive Emergency Management
American Red Cross
University of Utah Seismograph Stations
Utah Geological Survey
Utah Office of Education
Utah Division of Occupational/Professional Licensing
Utah League of Cities and Towns
Utah Association of Counties
Uniform Building Code Commission
Structural Engineers Association of Utah
American Institute of Architects, Utah Chapter
American Society of Civil Engineers, Utah Chapter
Association of Engineering Geologists, Utah Chapter

Resources Needed

First year: two person years: $80,000; materials: $75,000.
On-going: training: (1-3 FTEs) $40,000 to $120,000; materials: $15,000.

STRATEGY: Incorporate earthquake education in school curricula.

OUTPUT: A multi-level curriculum for earthquake education in all public schools.

OUTCOME: All students are provided with earthquake science and safety training as a part of their regular education.

Background

More than 468,000 students (approximately 26% of Utahns) are in grades K-12 in Utah schools. Incorporation of earthquake science and safety in the school curriculum will better ensure student safety now and help produce educated citizens who will be able to make responsible decisions in the future.

Implementation

It would be most appropriate to focus efforts for lesson plans at grade levels 3, 5, and 9 in conjunction with earthquake science or related topics in the State Science Core Curriculum. The objective can be accomplished by doing the following: (1) educating the curriculum providers – district level school boards, school administrators, and teachers' unions – about the value of earthquake education in schools and the ease with which that can be implemented, (2) developing Utah-relevant earthquake education materials and a variety of options for implementation, (3) establishing certification standards for earthquake education programs, and (4) providing teacher in-service workshops. Resources to carry out this program must be provided or made available as opposed to redirecting existing resources.

Responsible Agencies

Earthquake Education Resource Group (includes Utah Geological Survey, University of Utah Seismograph Stations, and Utah Division of Comprehensive Emergency Management)
Utah Office of Education

Resources Needed

A task force composed of earthquake scientists and educators and members of the target audience (teachers and administrators) could develop and implement the entire project. Salaries would be needed for 1.5 FTE for three years as well as additional funds for office supplies and curriculum materials. The estimated total expenditure is $80,000 to $100,000 per year for three years.

STRATEGY: Disclose geologic hazards in real-estate transactions.

OUTPUT: Homebuyers are made aware of geologic hazards at a property prior to making a purchase.

OUTCOME: Homebuyers are more informed in their decisions.

Background

Buying a home is probably the greatest investment most families make in a lifetime. In making a decision on purchasing a home, they need accurate information. A commonly overlooked concern is geologic hazards because most homebuyers are unaware of geologic hazards and falsely assume that government would not allow homes to be built in hazardous areas. Homebuyers need to know the risks they are incurring. There is presently no easy way for homebuyers or real-estate agents to know if a property is vulnerable to geologic hazards.

A seller's disclosure form available to potential buyers would provide the necessary information. The Utah Association of Realtors has a voluntary disclosure form which includes geologic hazards that they recommend be used by all realtors. The Utah Division of Real Estate is presently developing a "property condition" disclosure form including geologic hazards which will be required in all transactions involving a real-estate broker, but it will not be required in non-brokered transactions.

Implementation

Disclosure can be implemented at either the state or local government level. Uniformity statewide is desirable, and would require legislation. Accurate maps showing geologic hazards are useful to inform sellers, real-estate agents, and local governments of potential hazards, but aren't necessary to implement disclosure if only known hazards or damage from hazards are to be disclosed.

Responsible Agencies

Utah Division of Real Estate
Local governments
Utah Geological Survey (to provide hazards information)

Resources Needed

If responsibility for disclosure is placed with sellers or real-estate agents, no government funding is necessary. Minimal costs may be incurred in handling paperwork. If the state places responsibility with local governments, state or local funds to handle additional paperwork may be required.

Objective 2:

Improve emergency response and recovery.

STRATEGY: Establish community emergency response teams (CERTs) statewide.

OUTPUT: Trained volunteer community emergency response teams exist statewide.

OUTCOME: Reduce life, property, and environmental loss by providing more immediate response in a disaster.

Background

In the immediate aftermath (first 72 hours) of an earthquake, standard emergency services will not be available. Research has shown that most rescues and emergency services are provided by untrained volunteers spontaneously functioning in damaged neighborhoods. This initiative would provide very basic training for interested people in fire safety, light rescue, disaster medical operations, hazard inspection, and other services. Grouped together within each community, as a part of neighborhood groups, church groups, or professional organizations, these volunteers would be in place to act independently and spontaneously in the event of a disaster, known and trusted by the people they are helping. These volunteers will respond to their neighborhoods first, then go to staging areas to assist their local government's disaster efforts.

Implementation

Four steps are required: (1) orient elected officials, policy makers, police, and fire and emergency management personnel in the use of volunteers in disaster response; (2) identify citizen groups and volunteer organizations; (3) distribute information and hold workshops through local public safety organizations and community service groups; and (4) continue to provide technical assistance and recertification to CERTs wishing to provide community-based relief. The steps would be accomplished under the direction of local Emergency Program Managers, with assistance of fire and rescue agencies to train volunteer community emergency response teams and team leaders.

Responsible Agencies

- Utah Division of Comprehensive Emergency Management (CEM)
- Local Emergency Program Managers
- Fire and medical agencies
- Community groups of all types

Resources Needed

Funding needed to provide CERT instructors to train local volunteers groups, to provide CERT safety equipment and basic supplies, and to manage and track statewide CERT teams and resources: approximately $100 per volunteer. Local governments within Salt Lake County began pilot training programs in 1994. Trainers currently volunteer their time free-of-charge. CEM would like to provide CERT training to 30 Utah communities with populations of 100,000 or less, annually. It would take about 15 years to offer training to most communities statewide. If training for two classes of 25 volunteers each are run in each of 30 communities, annual cost would be approximately $150,000.

STRATEGY: Develop effective exercise and training programs for hospitals.

OUTPUT: All hospital staff are trained for earthquake emergency response including implementing a standardized triage system.

OUTCOME: Hospitals are prepared for earthquake response.

Background

Past exercises have revealed inadequacies in response-related operations. Hospitals need to ensure their facilities are operational after an earthquake. This would require training and exercising hospital response plans, as well as interaction between hospitals and coordination with local emergency management officials. Hospitals need to routinely schedule exercises individually and in conjunction with other hospitals and local officials. All hospitals should exercise using a standardized triage system with universal triage tags. This system would save time, lessen confusion, and, most importantly, save lives. A universal triage system would be critical in mutual medical aid situations where emergency room staff are working in hospitals other than their own.

Implementation

There are six elements to preparing Utah hospitals for an earthquake emergency: (1) accurately identify each hospital's capabilities and seismic vulnerability; (2) enhance communication for air traffic at each hospital; (3) train hospital staff on ARES/RACES (amateur radio operators emergency systems) capabilities; (4) provide training as part of the hospital's policies; (5) establish continuing education goals; and (6) standardize hospital triage systems and encourage comprehensive seismic safety education programs for hospital personnel. Exercises to test hospital emergency response plans should be held periodically.

Responsible Agencies

- Utah Division of Comprehensive Emergency Management (CEM)
- Utah Hospital Association
- Utah Department of Health
- Local emergency management officials
- Local governments
- Local fire and police departments

Resources Needed

CEM's Exercise Program specializes in writing and conducting exercises. Developing and conducting a hospital-specific earthquake-scenario exercise centered around a standardized triage system would cost approximately $50,000.

STRATEGY: Enhance communication capabilities for emergency responders.

OUTPUT: Develop a communication system that will allow for the use of new technologies and provide the capability of expansion during peak disaster use.

OUTCOME: Emergency response capability will be enhanced because the new communication system will allow for the interoperability of agencies to meet the requirements of multi-agency response.

Background

Public safety and local governmental agencies in Utah currently operate radio systems in the VHF 150 and UHF 450 frequency band. The availability of additional frequencies in these two bands for system expansion is very limited. With the advancement of technology comes the responsibility to develop a system that will allow for the use of this new technology. We must ensure that the system allows for the interoperability of agencies to meet the requirements of multi-agency response. Most agree that radio coverage, combined with inadequate channel allocations, are the biggest problems in meeting the objectives of protection of life and property. During emergency situations, history continues to repeat itself with the inability of agencies to communicate with each other in an effective manner.

Implementation

A new communication network that will support both voice and data applications and accommodate current and future requirements needs to be developed. The system should support city, county, state, and federal agencies. All government agencies that are users or will have future communication needs will be requested to evaluate their present capabilities and their future communication requirements.

Responsible Agencies

- Utah Division of Information Technology Services
- Utah Department of Public Safety
- ARES/RACES (amateur radio operators organizations)
- Local governments
- State agencies

Resources Needed

An 800 MHz system is currently being evaluated for future communication needs for the state, including emergency response. Preliminary estimates indicate the initial phase of conversion from the present system will cost up to $10 million.

STRATEGY: Enhance the integrated emergency management system statewide.

OUTPUT: An integrated emergency management system at all levels of government and the private sector to protect life, health, property, and the environment.

OUTCOME: All jurisdictions and agencies can more fully utilize their resources to respond to any type of a disaster, including earthquakes.

Background

As Utah's population, infrastructure, and economy continue to grow, it becomes an increasing challenge for all agencies to inventory and utilize their resources. City, county, and state governments have designated Emergency Coordinators to prepare and conduct mitigation, preparedness, response, and recovery operations. These Coordinators are also responsible for exercising and evaluating their plans. Emergency planning and operation evaluation is an ongoing process. This should lead to a higher level of response proficiency.

Implementation

Encourage a full-time Emergency Coordinator for each state agency. Increase training in Integrated Emergency Management concepts. Continue to exercise emergency plans.

Responsible Agencies

Utah Division of Comprehensive Emergency Management
State Emergency Response Teams (SERT)
County emergency management offices

Resources Needed

Funding for 1 FTE Emergency Coordinator in each of the 25 largest state agencies would cost approximately $48,500 per coordinator, or an approximate annual cost of $1,212,500.

Objective 3:

Improve the seismic safety of buildings and infrastructure.

STRATEGY: Improve plan review procedures on new construction to ensure that buildings are being designed in accordance with current seismic code requirements.

OUTPUT: Competent plan reviews are completed for new construction.

OUTCOME: Help ensure that new buildings are being designed safely by competent professionals to withstand seismic forces.

Background

Many municipalities have some form of plan review to ensure that buildings are being designed in accordance with the Uniform Building Code (UBC). However, a lot of buildings are built which do not meet current seismic code requirements, particularly in rural portions of Utah where plan checking is not performed.

Implementation

Mandate that important structures, such as schools, hospitals, or emergency response facilities, particularly those located in seismic zone 3, have a plan review by a competent professional before a building permit is issued. Require plan reviews on all construction over a certain height and/or size in cities and towns located in nonrural counties, particularly Davis, Utah and Salt Lake.

Responsible Agencies

Structural Engineers Association of Utah
International Conference of Building Officials, Utah Chapter
Local governments

Resources Needed

Salary of competent in-house reviewer: $35,000 to $60,000 per year; or outside consultants: $500 to $2,000 per structure.

STRATEGY: Enforce the state amendment to the Uniform Building Code which requires building owners to install roof anchors and parapet bracing when reroofing their buildings.

OUTPUT: Copies of the amendment are distributed to building officials, architects, and engineers through the media and professional societies, and education programs are conducted.

OUTCOME: A gradual decrease in the seismic hazard posed by existing unreinforced masonry buildings.

Background

Unreinforced masonry structures built prior to 1976 pose a great risk to life safety during even moderate earthquakes. The weakest structural link is frequently the connection between the roof structure and supporting walls. A failure at this location can lead to collapse of the roof. Also, unreinforced parapets and appendages are particularly vulnerable to collapse if not properly anchored.

The logical time to perform this work at least expense is during reroofing when the roof structure is exposed, and new ties and braces can be easily installed. Ordinances similar to the amendment have worked successfully in Ogden and California cities.

The Uniform Building Code (UBC) Amendment was passed by the Utah UBC Commission in 1993, but has not been enforced, partially due to lack of knowledge of the amendment by building officials, or by building owners contracting reroofing without first obtaining a building permit, thereby bypassing the amendment requirement.

Implementation

Educate building officials, engineers, and architects of the amendment through the media, professional organizations, and the State Division of Occupational/Professional Licensing. Enforce the requirement to obtain a building permit before allowing people to reroof their buildings.

Responsible Agencies
- Structural Engineers Association of Utah
- American Institute of Architects, Utah Chapter
- International Conference of Building Officials, Utah Chapter
- Division of Occupational/Professional Licensing
- Uniform Building Code Commission

Resources Needed
- Minimal.

STRATEGY: Improve the post-earthquake operational status of essential service buildings.

OUTPUT: All essential government services buildings are identified. Buildings constructed before 1976 are retrofitted or relocated as needed, to meet standards that will allow them to remain operational after earthquakes.

OUTCOME: The ability to provide uninhibited disaster relief services.

Background

Lessons learned in recent damaging earthquakes demonstrate the need to continue essential government services during and after an earthquake. Many facilities constructed during periods when codes were not as comprehensive as current codes have sustained damages that restrict their use after an earthquake. Precautions must be taken to determine acceptable levels of facility performance to ensure post-earthquake availability of functions. Older essential services buildings that house emergency operations centers, law enforcement offices, and fire stations may not be able to remain functional after earthquakes. The potential loss of these functions poses an unacceptable risk because it would slow emergency response and result in unnecessary casualties and property damage.

Implementation

Using a uniform assessment procedure, the cataloging of location, hazard type, and structure vulnerability should be undertaken. Retrofit or relocation possibilities are then analyzed. Cost/benefit information is compiled and analyzed. Mitigation is then undertaken on a priority basis.

Responsible Agencies:

Local governments
Utah Division of Facilities Construction and Management

Resources Needed

A rapid visual screening assessment costs approximately $1,500 per building.

Funding to rehabilitate the facilities on a priority basis depends on results of assessment.

STRATEGY: Reduce structural hazards of government-owned buildings.

OUTPUT: Government-owned buildings structurally modified to better withstand earthquakes.

OUTCOME: A safer environment to conduct government business.

Background

State and local governments own a great number of buildings. Some have unreinforced masonry walls or are made of nonductile concrete or other materials likely to collapse during an earthquake. In past earthquakes, these facilities have suffered higher losses than other construction-type facilities. The public, government employees, and government functions—including many emergency services—are at risk because of these buildings. The state owns approximately 4,500 buildings of which approximately 2,300 would be considered essential in the event of a catastrophic event.

Implementation

Complete a program to ensure that major state government buildings can withstand an earthquake to the extent that collapse is precluded, occupants can exit safely, and functions can be resumed or relocated promptly consistent with the need for these services after earthquakes. Essential buildings would need to be identified and prioritized in terms of the necessity for their use to supply essential services after a catastrophic event. ATC-21, the rapid visual screening of buildings for potential seismic hazards could then be used to identify buildings by design and vulnerability parameters. Based on these parameters, buildings should then be prioritized by order of essential need and vulnerability to a seismic event. Detailed evaluations and cost estimates should then be generated for the retrofitting or replacement of each of the facilities, including a timetable for completion of the work.

Responsible Agencies

> Utah Division of Facilities Construction and Management
> Local governments

Resources Needed

> Rapid visual screening to identify and catalogue government buildings structurally at risk in a seismic event averages $1,500 per building. Funding to conduct geologic investigation of the building site averages $2,000 per site. The total cost to evaluate 2300 essential state-owned buidings would be $3,450,000 for the buildings themselves and $4,600,000 for the geologic site evaluations, or approximately $8,050,000.
>
> Cost for detailed evaluation of at-risk government buildings averages $5,000 per building when done on individual buildings. Evaluations conducted on groups of buildings can be considerably less costly.
>
> Costs to upgrade government-owned buildings ranges from $8.75 to $18.00 per ft^2. Cost to carry out needed seismic upgrade of buildings will depend on results of assessment.

STRATEGY: Mitigate nonstructural hazards in government-owned and leased buildings.

OUTPUT: Assess hazards in government-owned buildings and upgrade as necessary.

OUTCOME: A safer and operational working environment for government agencies following an earthquake.

Background

Falling hazards to occupants and visitors can be posed by nonstructural building elements such as parapets, cornices, ceiling and lighting systems, window and building cladding systems, air conditioning, and plumbing and electrical equipment. These hazards are significant to the continuity of building functions following earthquakes.

The seismic safety of nonstructural elements in all new construction is largely regulated by building codes. Before 1976, however, most building codes failed to explicitly regulate the seismic safety of nonstructural elements. As a result, nonstructural elements in older buildings are often unbraced or unattached to the structure and can fall or move excessively during earthquakes.

Implementation

Perform an evaluation of government-owned and leased buildings with regard to falling hazards in existing nonstructural building elements. The evaluation would identify and prioritize these elements with regard to level of danger presented. A cost estimate for correcting each hazard would be part of the evaluation. Upon completion of the evaluation, appropriate action can be undertaken.

Responsible Agencies

Utah Division of Facilities Construction and Management
Agencies and institutions that are responsible for facilities
Local governments

Resources Needed

If evaluation of nonstructural hazards is performed during investigation of structural hazards (see Strategy 3.4) in the same building, additional cost would be approximately $100 per building.

Cost to carry out seismic upgrade will depend on results of evaluation.

STRATEGY: Improve safety of older public school buildings.

OUTPUT: Identify and reduce structural and non-structural seismic hazards in all pre-1976 public school facilities.

OUTCOME: Safer facilities for students and teachers, as well as buildings useable in an emergency.

Background

A large number of public school buildings were designed prior to the 1976 Uniform Building Code seismic requirements. Additionally, some recent portable classrooms may not be adequately anchored to their foundation. Many schools have free-standing bookshelves, file cabinets, and other heavy shelved items that are not secured and may cause harm. A major earthquake may cause significant property damage and injury to students and teachers. Additionally, these damaged structures will not be available for disaster relief efforts.

Implementation

Identify all schools and their associated hazard, structural, and non-structural problems. Initiate plan to mitigate, rebuild, or relocate the public school structures, and create a priority list to determine which buildings are the most hazardous. Study minimal cost methods of partially retrofitting schools, such as providing connections between wall and roof structures.

Responsible Agencies

Utah Office of Education
Individual school districts

Resources Needed

Funding for seismic studies provided in school district taxing policies. Studies by Salt Lake School District averaged $1,000 per building. These studies were done on a group basis. A projected range would be from $500 to $5,000 per building, and would depend on the complexity of the structure and the degree of detail required in the study. Over one-third of these assessments have already been done. Total cost for assessments of all school buildings would be on the order of $720,000.

Funding and technical expertise for seismic upgrades also funded by school district taxing. Costs for upgrades in Salt Lake averaged $833,333 per school, but costs will vary as indicated in the assessments. If the statewide average upgrade costs $500,000 per school, the total cost would be about $300 million.

STRATEGY: Improve safety and operational ability of older hospital buildings.

OUTPUT: Assess earthquake vulnerability of all hospitals and upgrade the structures to better survive an earthquake.

OUTCOME: Safe structures that will provide a more secure environment for patients and staff and improved ability to survive an earthquake and provide disaster relief.

Background

Many Utah hospitals were designed prior to the 1976 Uniform Building Code seismic requirements. A major earthquake may cause significant property damage and injury to patients and health-care providers. Of equal concern, these damaged structures will not be available for disaster relief efforts after an earthquake.

Implementation

Hospitals should remain operational after an earthquake. A risk and vulnerability analysis of the structures should be performed. Upgrade the structural and non-structural components as required.

Responsible Agencies

Uniform Building Code Commission
Utah Division of Comprehensive Emergency Management
Privately owned and county hospital organizations

Resources Needed

Cost of seismic studies could range anywhere from $1,000 to $10,000 per structure depending on building size, complexity, and degree of detail desired in the study. Many Wasatch Front hospitals have already been evaluated.

Cost for seismic upgrades depend upon vulnerability but can be generalized between $8.75 to $25.00 or more per ft^2.

STRATEGY: Improve safety of older high-occupancy buildings (250 persons or more) to be structurally competent enough to withstand moderate to large earthquakes.

OUTPUT: Assess seismic vulnerability of all older high-occupancy structures and retrofit or disclose building condition upon resale.

OUTCOME: Prevent collapse in the event of an earthquake, thus reducing life loss, property loss, potential secondary effects, and reconstruction costs.

Background

High-occupancy buildings designed prior to the 1976 Uniform Building Code seismic requirements are of special concern because of the potentially significant loss of life and injury. Efforts should be made to insure against structural collapse and non-structural failure.

Implementation

Identify all high-occupancy buildings in the state. Assess each structure to determine vulnerability and propose mitigation techniques and costs. Require disclosure of hazards and building condition upon resale. Find funding sources and incentives to help building owners mitigate the hazards. A publication by the Applied Technology Council (ATC-33) provides seismic rehabilitation guidelines for existing buildings.

Responsible Agencies

Utah Division of Comprehensive Emergency Management
Uniform Building Code Commission
Local governments

Resources Needed

Cost of vulnerability studies are approximately $1,000 to $4,000 per building.

Cost for seismic upgrades for public facilities is $5 to $25 or more per ft^2.

Technical expertise and guidelines for seismic upgrades.

Local government agencies enact and enforce new regulations.

STRATEGY: Improve the seismic safety of older homes.

OUTPUT: Create and distribute maps of seismic-hazard areas and upgrade information packets, procedural manuals, standards, and requirements to all affected home owners, all real-estate agents, building contractors, and lending institutions. Establish funding sources and incentives to encourage seismic-safety retrofitting.

OUTCOME: Improved safety and lower repair costs in the event of an earthquake.

Background

There are many unreinforced masonry houses along the Wasatch Front which are susceptible to seismic damage. Many older frame houses were built without adequate anchorage to their foundations. Water heaters and other non-structural elements are usually not anchored to resist earthquakes.

Implementation

The first step is to create and distribute an information packet describing hazards, general procedures, standards, funding sources, and incentives to the homeowners. Technical and procedural documents are to be made and dispensed upon request. Funding and incentive packages should be created by public and private industries such as insurance and mortgage companies. One publication, available through the Utah Division of Comprehensive Emergency Management, describes methods for seismically upgrading older, unreinforced masonry homes.

Responsible Agencies

Utah Division of Comprehensive Emergency Management
Utah Division of State History
Uniform Building Code Commission
Real-estate, insurance, and mortgage groups

Resources Needed

Cost to develop a household earthquake upgrade information packet and technical and procedural documentation (booklets available through State agencies and from the Federal Emergency Management Agency) approximately $40,000.

Financial incentives to encourage homeowners to make seismic retrofits.

STRATEGY: Improve safety of mobile homes.

OUTPUT: Seismically brace all new mobile homes; retrofit inadequately braced existing mobile homes at time of resale. Create and implement incentive packages to encourage mobile home owners to retrofit existing installations.

OUTCOME: Increased safety for occupants, reduced amounts of utility rupture and associated hazards and repair costs.

Background

Mobile homes are extremely vulnerable to earthquake damage. Since mobile homes are virtually never connected to a foundation, they tend to fall off their supports during an earthquake, often severing their typically rigid gas and water connections. This can lead to fire and rupture of water lines.

Implementation

Identify locations where bracing and retrofitting is appropriate. Legislation is needed to require new mobile homes to be seismically braced and existing mobile homes be retrofitted at time of resale. Provide tax or insurance incentives to those who mitigate.

Responsible Agencies

Utah Division of Motor Vehicles
Local government

Resources Needed

Cost of seismic bracing on new installations will be part of the installation price paid by homeowners but is unknown at this time.

Provide financial incentives to retrofit existing installations. California requirements and industry standards for wind anchorage can accomplish retrofit requirements if enforced.

Local governmental agencies enact and enforce new regulations.

STRATEGY: Prevent loss of historic buildings.

OUTPUT: Vulnerability assessments and mitigation completed on buildings on the National Historic Register.

OUTCOME: The preservation of historic buildings and their associated heritage in the event of an earthquake.

Background

Utah's designated historic buildings are an irreplaceable cultural resource. Many of these structures are likely to be damaged beyond repair by an earthquake. The problem is compounded by the lack of funding to reinforce these buildings in a way that preserves their historic and architectural qualities. After an earthquake, damaged historic buildings should not be demolished without thorough review.

Implementation

Identify and then reduce seismic hazards in all "National Register" historic buildings. Provide mitigation solutions and aid in the creation and acquisition of funds needed to make the necessary upgrades.

Responsible Agencies

Utah State Historical Society for privately owned buildings
Utah Division of Facilities Construction and Management for state buildings

Resources Needed

Funds needed for assessments on approximately 1,000 sites. Assessment and retrofit costs for historic structures are much higher than for other buildings.

Money and technical expertise for seismic upgrades depends on results of assessments.

STRATEGY: Improve lifeline survivability in the event of an earthquake.

OUTPUT: Assess and mitigate earthquake hazards on all lifelines.

OUTCOME: Functional or easily/rapidly repairable lifelines after a earthquake.

Background

Critical elements of the infrastructure of many utilities and other lifelines are vulnerable to damage during earthquakes. Within the electric power network, porcelain insulators and certain pole-mounted transformers may have a high probability of failure. Telecommunications switching equipment, as well as transceiver towers and conduits may be displaced or moved out of alignment. Liquid and gaseous fuel pipelines and petrochemical tanks may be displaced or ruptured.

Implementation

State, county, and local public works departments in conjunction with utilities should survey, inventory, and assess the condition of their respective lifelines. Upon completion of the assessment, plans for mitigation and or replacement should be developed and implemented. Emergency response plans should be developed, and seismic considerations incorporated into the design of new lifelines.

Responsible Agencies

Utah Public Service Commission
Uniform Building Code Commission
Federal Energy Regulatory Commission
Municipal and private utilities and pipeline operators

Resources Needed

Regulatory rate consideration from Utah Public Service Commission, Federal Energy Regulatory Commission or local government.

Cost for assessing lifeline vulnerability not available at this time.

Cost for lifeline upgrades depends upon results of assessments.

STRATEGY: Improve earthquake performance of water and waste-water systems.

OUTPUT: Establish appropriate and practical uniform safety and emergency response plans for all water and waste-water systems.

OUTCOME: Improved safety, performance, and reliability of water and waste-water systems.

Background

Culinary and waste-water systems include aqueducts, pumping stations, transmission pipelines, water and waste-water treatment facilities, distribution and collection pipe networks, and distribution storage tanks and reservoirs, all of which are vulnerable to earthquakes. Water and waste-water systems can be rendered inoperable because of damage to tanks, reservoirs, treatment facilities; broken transmission mains; failures at pipe joints; and failed equipment. Damages from water sloshing in tanks and clarifiers is unavoidable during earthquakes, but economical, preventive measures can be taken to reduce the amount of damage and recovery time after earthquakes. Many of the state's water systems' transmission mains and aqueducts cross active faults and dormant landslide zones, and are vulnerable to fault rupture or earthquake-caused slope failure. Because most of the transmission systems are underground, localized damage to such systems is unavoidable. Water and waste-water systems should stockpile replacement components needed after earthquakes.

Implementation

All water and waste-water systems should be inventoried to assess their earthquake performance. All water and waste-water systems would identify and report their emergency-response plans and procedures for the timely repair or replacement of earthquake-damaged water and waste-water systems. Establish appropriate and practical, uniform seismic-safety criteria and procedures and adopt a comprehensive policy on acceptable levels of earthquake risk in water systems. A report should be made to the state legislature that will make recommendations for any additional authority needed to develop and enforce an effective policy on acceptable earthquake risk, including uniform seismic-safety standards, and emergency-response and recovery plans if required.

Responsible Agencies

Utah Department of Environmental Quality
Water system owners (local governments, sanitation districts, etc.)
Waste-water system owners (local governments, sanitation districts, etc.)

Resources Needed

Cost to assess systems not available at this time.

Cost to the state to establish safety criteria and policies on acceptable risk unknown at this time.

Cost to upgrade systems depends upon results of assessments.

Objective 4:

Improve essential geoscience information.

STRATEGY: Reduce earthquake losses by mapping and identifying geologic hazards.

OUTPUT: Hazard maps for all earthquake-prone urban areas.

OUTCOME: Development and management are safer, more reasoned, and more cost-effective.

Background

Strong ground shaking, liquefaction, slope failure, surface fault rupture, and other forms of ground failure are responsible for most losses caused by earthquakes. Changes in ground water conditions caused by earthquakes can also have major, sometimes permanent, consequences. Areas subject to these hazards need to be identified and mapped by qualified professionals so that information can by used by local governments in land-use ordinances and by others in adequately considering geologic hazards in development and management. Geologic-hazard maps for certain hazards are complete for much of the Wasatch Front from Ogden to Provo, but remain to be done in other urban areas subject to earthquake hazards. The Utah Geological Survey (UGS) has a long-term goal to complete these maps statewide, but the process will take decades. To accelerate the program, 1-2 additional UGS staff would be needed. To help ensure that local governments use the maps, UGS presently requires contributions from local governments. Experts in the private/academic sector may also complete some the hazard mapping. Certain hazards such as strong ground shaking require additional research and data collection to develop suitable databases and techniques to produce maps.

Implementation

Geological hazards mapping is ongoing at the UGS and will continue. Maps for some hazards could be completed by university or private-sector specialists.

Responsible Agencies
- Utah Geological Survey
- Local governments
- University geology departments, private geologists

Resources Needed
- UGS staff (1-2 FTE's): $40,000 to $80,000 per year.
- Local government cost sharing: $5,000 to $10,000 per city.
- Private/academic mapping: $50,000 to $100,000 per project.

STRATEGY: Perform geologic-hazards investigations for critical public facilities.

OUTPUT: Geologic-hazard investigations are performed for all new critical public facilities.

OUTCOME: Critical facilities will not be sited in hazardous areas and, in the event of a natural disaster, facilities that are needed for emergency response will remain intact.

Background

Critical public facilities (schools, water tanks, public-safety buildings, etc.) are still being sited in hazardous areas, sometimes with no knowledge of hazards and sometimes with knowledge coming too late to abandon sites or alter designs without incurring great additional expense. Many governments require private developers to consider geologic hazards, but do not themselves consider hazards in locating their own buildings.

Certain public buildings are critical for public safety during and after a disaster. These buildings must not be vulnerable to geologic hazards that could endanger occupants or reduce functionality following a disaster such as an earthquake when they are needed most. The consequences will be reduced capacity to house and feed those needing shelter after a disaster, reduced response capability, possible loss of life in public buildings with accompanying liability, and government losses due to property damage.

Implementation

Legislation could be passed requiring such investigations, performed either by the private sector or by the Utah Geological Survey (UGS).

Responsible Agencies

- Local governments
- Utah Geological Survey
- Utah Division of Facilities Construction and Management (DFCM)

Resources Needed

DFCM already requires such investigations by the private sector for buildings they administer as a part of their building costs. Local governments would similarly need to fund such costs if done by the private sector. Under the Utah Code, the UGS is charged to perform geologic-hazards investigations for schools and local government critical facilities, but because of declining budgets the UGS cannot take on an increased workload without additional funding. The UGS may need 1-2 additional staff ($40,000 to $80,000 per year) to perform these studies, depending on workload.

STRATEGY: Make land use compatible, through local government ordinances, with known hazards.

OUTPUT: Local governments are encouraged or required to adopt geologic-hazards ordinances as needed.

OUTCOME: Land use is safer and consistent with identified geologic hazards.

Background

In Utah, local governments regulate land use. One critical life-safety and property-loss element that should be considered in land use is geologic hazards. Land uses must be compatible with hazards present, and often hazards must be reduced prior to use.

Damages from unwise land use in Utah have principally been from landslides, debris flows, flooding, and soil-foundation problems. However, earthquakes present the potential to cause damage and life-loss far exceeding that from other hazards. This potential loss can be reduced by prudent land use. Governments may be incurring liability by allowing development in hazardous areas.

Implementation

Legislation or state policy requiring (or encouraging) local governments to adopt geologic-hazards ordinances is needed. Many local governments already have such ordinances but do not adequately enforce them. Once implemented, geologic assistance from the Utah Geological Survey (UGS) to review reports will be required. Sample ordinances and guidelines for developing and enforcing ordinances are already available.

Responsible Agencies

Local governments
Utah Geological Survey

Resources Needed

No legislative appropriation is necessary; costs principally to be born by private developers, typically $1,000, perhaps up to $3,000 per project. Some staff costs to enact ordinances will be incurred by local governments, and costs to provide technical assistance to enforce ordinances will be incurred by the UGS. Costs for report reviews can be passed on to developers. Total costs to developers statewide would be on the order of $300,000 per year (based on 250 studies per year).

STRATEGY: Ensure design professionals and building officials are kept current on relevant geoscience information.

OUTPUT: Periodic meetings of geoscientists, engineers, and building officials to discuss implications of geoscience information to building safety.

OUTCOME: Up-to-date, reliable geoscience information is used to guide the safe and economical earthquake-resistant design of new buildings.

Background

Seismic requirements for construction in Utah are contained in the Uniform Building Code (UBC), adopted statewide in 1987. UBC requirements are based on two geoscience factors: (1) the seismic zone rating taken from the UBC Seismic Zone Map (derived from a map of peak horizontal ground accelerations with a 10 percent probability of being exceeded in 50 years) and (2) the site coefficient, taken from site soil information. Information with relevance to seismic zone factors and site coefficients is constantly evolving through scientific research and experience in recent earthquakes.

Geologists, seismologists, and geotechnical engineers must look at new information and lessons learned in recent earthquakes with regard to their implications for building safety in Utah, and keep structural engineers, building officials, and policy-makers aware of pertinent findings and their implications to building codes.

Implementation

New geologic, geotechnical, and seismologic (particularly strong-motion) data must be analyzed and applied to building safety. Various disciplines must coordinate activities and perform evaluations and reviews of pertinent information.

Responsible agencies

- Utah Geological Survey
- University earth-science and engineering departments
- American Society of Civil Engineers, Utah Chapter
- Association of Engineering Geologists, Utah Chapter
- Structural Engineers Association of Utah
- International Conference of Building Officials, Utah Chapter
- American Institute of Architects, Utah Chapter
- Uniform Building Code Commission

Resources Needed

Resources are needed for participation in post-earthquake investigations and key conferences and to convene local workshops; approximately $10,000 per year.

STRATEGY: Determine appropriate seismic criteria and procedures for evaluating performance of existing dams.

OUTPUT: Guidelines for seismic safety assessments of existing dams.

OUTCOME: Uniform, state-of-the-art assessments of seismic safety of dams.

Background

The State of Utah has a program for protecting public health and welfare by regulating the safety of several hundred existing dams. Among the issues considered in this program is the performance of dams under seismic loading. Current regulations require estimation of the maximum acceleration and an "operating-basis" acceleration at each dam determined to have questionable future performance. These regulations require embankments to have "acceptable" deformations under maximum acceleration loading and essentially no deformations under the operating-basis acceleration. The reliability of deformation predictions is of concern with respect to public safety. Are procedures for predicting earthquake ground motions and embankment deformations sufficiently reliable that relatively little post-deformation freeboard should be required? Or are these procedures sufficiently uncertain that the predicted deformations could result in dangerous overtopping? Should the operating basis acceleration be defined as the largest likely to be experienced during the useful life of the dam or a period of economic depreciation?

Costs of rehabilitation of existing dams can be extremely high, and many dams are owned by rural water districts that depend on the water but do not have spare financial resources. The State is charged with protecting public health, safety, and welfare; the dam owners are charged with maintaining their facilities and providing water for the welfare of people in their service areas. Accurate acceleration values and reliable procedures for evaluations of dam seismic response are important for state agency personnel and dam owners to maintain safe and economical dams.

Implementation

This strategy requires two parts: (1) a detailed evaluation of maximum earthquakes together with attenuation of ground motion with distance, and (2) a detailed evaluation of the reliability of alternative procedures for predicting the seismic response of dams.

Responsible Agencies

Utah Department of Natural Resources, Division of Water Rights

Resources Needed

Research for this initiative is estimated at $200,000 over a two-year period.

STRATEGY: Reduce earthquake-induced liquefaction risk to highway structures.

OUTPUT: Identify all hazardous bridges; generate a plan for mitigation of each structure.

OUTCOME: Highway bridges are safer in the event of earthquake-induced liquefaction.

Background

Earthquake-induced liquefaction is a major cause of earthquake damage to bridges. Areas prone to liquefaction include floodplains and other lowland areas where water tables are shallow and sediments are of recent deposition. For example, 266 highway and railway bridges were damaged or destroyed during the great 1964 Alaska earthquake due to ground displacements generated by liquefaction. Similar, but less extensive bridge damage occurred during earthquakes near Charleston, South Carolina, in 1886; San Francisco, California, in 1906 and 1989; and in the Imperial Valley of California in 1979.

Several areas of Utah have been identified as susceptible to liquefaction during moderate to large earthquakes. Some segments of major roadways, including Interstate highways and primary arteries, and many segments of secondary routes cross these potentially hazardous areas. A survey of bridges and bridge sites is needed to assess which bridges may be vulnerable to liquefaction-induced damage. This assessment could then be used to develop a mitigative plan to prevent or minimize damage and disruption to the highway system during future earthquakes.

Implementation

An assessment should be made of highway bridges in the state to determine their vulnerability to liquefaction-induced damage. Plans should then be made to reduce hazards through retrofit or replacement.

Responsible Agencies
Utah Department of Transportation
Help from specialists from universities and other state agencies in Utah

Resources Needed
Funding needed for assessment: $300,000.

Cost of mitigation depends on results of assessments.

STRATEGY: Determine appropriate seismic design coefficients for highway bridges.

OUTPUT: Calculate and incorporate new seismic design coefficients in design work for new bridges associated with the widening of I-15.

OUTCOME: (1) Ensure that the best available information is used for the safe and economical design of the new bridges. (2) Prevent the need for retrofit of the bridges in the near future. (3) Reduce bridge damage in an earthquake.

Background

The design of new bridge structures for the I-15 corridor requires scientists and engineers to determine the seismic forces which will act on the bridge. Recent experiences in California indicate that soft deep and stiff shallow soil profiles can significantly affect ground motions at a site. While studies and evaluations of various soil types have been prepared in California, the results of these evaluations are not directly transferrable to the existing conditions in Utah.

There is considerable uncertainty regarding appropriate design accelerations for bridges in Utah. Examining the similarities in soil conditions and the potential for large earthquakes, current design requirements in Utah appear to be unsafe based on California's experience. However, direct application of design accelerations used in California may be overly conservative because of differences in the rates of earthquake occurrence in Utah and in California. Because bridge structure (superstructure and foundation) costs and earthquake resistance can vary significantly depending of the correct design acceleration coefficient, it is important to accurately estimate this value for safe and economical design.

Implementation

This strategy would require detailed subsurface investigations (to 200 ft) at several bridge sites with soil profiles typical of that along the I-15 alignment. Based on the soil information which is collected, computer models will be used to predict the ground motions which would develop for a number of potential earthquakes.

Responsible Agencies

Utah Department of Transportation
Help from specialists from universities within Utah

Resources Needed

It is estimated that costs for necessary geotechnical studies will total approximately $300,000.

STRATEGY: Develop incrementally a strong-motion program.

OUTPUT: Deploy at least 108 accelerographs in the seismic regions of the state to record strong ground shaking.

OUTCOME: The hazard of strong ground shaking from local earthquakes is better quantified so it can be correctly incorporated into safe, cost-effective design of buildings and other structures. Key information can also be rapidly available for crisis management.

Background

Measurements of actual ground-shaking are essential to ensure that buildings and structures in Utah are neither under-designed, posing a life-safety threat, nor over-designed, wasting precious resources. Engineers need, but lack, recordings of strong ground shaking from Utah earthquakes to design and construct earthquake-resistant structures (including buildings, highways, and dams) that are cost-effective. A 1989 blue-ribbon panel of national earthquake experts recommended that to obtain the necessary data, a minimum of 108 new strong-motion recording instruments (accelerographs) be installed in Utah. In 1992 the Utah Legislature appropriated $75,000 to the Utah Geological Survey (UGS) to begin a strong-motion instrumentation program, and an advisory committee of engineers and scientists was formed to guide the program. But funding was discontinued after one year. The need for strong-motion data for earthquake engineering persists--to be able to predict reliably what strong ground shaking must be anticipated and to know what forces damaged structures have experienced. Recent California earthquakes also emphasize that crisis managers quickly need reliable information on the severity and geographic extent of strong ground shaking for emergency response.

Implementation

The UGS and its strong-motion advisory committee believe that a viable strong-motion program can be established and maintained through an incremental approach. With creative planning, instruments can progressively be spread throughout the seismically dangerous areas of the state to optimize the chance of recording strong ground shaking wherever it occurs. To the extent feasible, innovative instruments will be purchased to allow at least some capability for rapidly assessing strong-motion information within minutes of a sizable earthquake along the Wasatch Front urban corridor in order to direct appropriate levels of response.

Responsible Agencies
- Utah Geological Survey
- University of Utah Seismograph Stations

Resources Needed

To purchase, deploy, and maintain 108 instruments over 20 years would have an annual ongoing cost of $150,000.

STRATEGY: Develop a statewide, real-time earthquake monitoring system.

OUTPUT: (1) Increased number of seismically vulnerable counties and cities in Utah for which continuous and accurate instrumental earthquake data are available. (2) Rapid emergency alert, within minutes after the occurrence of an earthquake in the Utah region, to state-agency officials, emergency managers, and the general public.

OUTCOME: Collect and distribute data needed (1) for more cost-effective earthquake engineering, (2) for more rapid and effective emergency response, (3) to reliably quantify earthquake dangers, and (4) to improve scientific understanding of local earthquake behavior, in order to better mitigate effects.

Background

Instrumental earthquake recording provides essential information needed by many state agencies and local governments for rapid emergency response, for the reliable assessment of earthquake hazards and risk, and for safe cost-effective earthquake engineering. Utah's existing seismographic network, operated by the University of Utah Seismograph Stations (UUSS), does not provide adequate instrumental coverage of many seismically dangerous parts of the state—especially outside the Wasatch Front area. Strong-motion instrumentation in Utah is greatly inadequate. Available technology, which is becoming commonplace elsewhere, needs to be incorporated to ensure automated, rapid communication of vital information—including the extent and severity of strong ground shaking—to emergency managers within minutes after any significant earthquake.

Implementation

The UUSS needs to transform Utah's existing seismographic network into a statewide, real-time earthquake monitoring system. This can be progressively accomplished in 5 years, providing coverage of all high-risk areas of Utah. Capabilities for real-time data processing and automated post-earthquake alert can be added to Utah's existing seismic network, but without effective coverage of rural Utah.

Responsible Agencies

- University of Utah Seismograph Stations
- Utah Geological Survey
- Utah Division of Comprehensive Emergency Management
- Utah Division of Information Technology Services

Resources Needed

The costs for a modest, but effective, state seismic system will require a one-time capital investment of approximately $1 million and additional ongoing costs of approximately $150,000 per year.

STRATEGY: Monitor faults using Global Positioning System (GPS) measurements.

OUTPUT: Regular monitoring of a network of GPS benchmarks.

OUTCOME: Strain buildup and ground deformation associated with faults are understood on a very detailed level, allowing more accurate estimation of the likelihood of large earthquakes and accompanying hazards.

Background

Precise surveys of ground deformation across active faults using GPS technology are a fundamental technique in modern earthquake monitoring. GPS has become the principal tool used in the National Earthquake Hazards Reduction Program for measuring the cycle of ground deformation before, during, and between large earthquakes. The value of GPS surveying was recently demonstrated in the Los Angeles basin where ground deformation was observed prior to the 1994 Northridge earthquake, indicating that rupture was likely on hidden faults such as the one that produced the magnitude 6.7 quake.

GPS measurements are particularly important in Utah for: (1) understanding how fast Utah's normal faults accumulate strain energy prior to large earthquakes, (2) assessing the likely locations and timing of future earthquakes, especially along the Wasatch fault, (3) identifying hidden faults that may underlie Utah's densely populated valleys, and (4) evaluating how the broad warping of the earth's surface during future large earthquakes may cause Great Salt Lake or Utah Lake to inundate neighboring areas.

Implementation

Utah needs a statewide network of GPS survey benchmarks that are systematically observed with a pool of at least five GPS receivers. This effort requires (1) a plan for periodic and prioritized surveys of Utah's major active faults, and (2) integration of GPS data collection with other earthquake monitoring and with high-precision surveying for state, county, and local engineering. A stable long-term funding base is essential.

Responsible Agencies

University of Utah Seismograph Stations
Utah Geological Survey
County Surveyors: Salt Lake, Davis, Weber, Box Elder, Utah, among others

Resources Needed

Approximately $150,000 would be required for one-time acquisition of five dual-frequency GPS receivers, together with ancillary equipment. Recurring costs for field operations, data processing, data archiving, equipment upgrades, and coordination with cooperating agencies would require about $70,000 per year.

Objective 5:

Assess earthquake risk.

STRATEGY: Update estimates of direct losses expectable from earthquakes.

OUTPUT: Comprehensive studies to estimate the potential losses of life, number of injuries, and damages to structures and lifelines from earthquakes of various magnitudes and locations.

OUTCOME: Earthquakes are placed in a proper policy perspective based on credible projections of losses and societal impacts; emergency planning is improved; and long-term hazard-reduction activities are prioritized.

Background

Utah's last comprehensive forecast of earthquake losses was published in 1976 and is out of date. Subsequent studies have restrictively analyzed losses, say, to buildings only, or apply to restricted areas, such as Salt Lake County. In 1991, the Federal Emergency Management Agency (FEMA) funded the non-profit, California-based Applied Technology Council (ATC) to develop methods to estimate losses, including casualties, and apply these methods to estimate losses associated with a magnitude 7.5 earthquake in Salt Lake County. This and a study by the University of Utah Geography Department considered only losses in Salt Lake County. FEMA and the National Institute of Building Sciences (NIBS) have also developed a draft methodology (planned for release in 1996) to estimate earthquake losses at various levels of detail, depending on available data bases and technical experience of those performing the analysis.

Implementation

In order to establish credible forecasts of earthquake losses in Utah, various methodologies, together with available information, must be carefully evaluated. This will require close coordination among technically diverse experts and the use of both scenario-based and probabilistic risk methods for damage and casualty estimates. Available methodologies include those developed by the ATC, FEMA/NIBS, and the University of Utah Department of Geography. The Utah Seismic Safety Commission can provide a suitable forum for coordinating the interdisciplinary teams and studies required to produce well-founded estimates of direct losses expectable from earthquakes in Utah. These estimates must account for significant differences due to time of day and season. Also, loss estimates are needed for specific classes of buildings, such as schools, and for different levels of ground shaking accompanying moderate to large earthquakes, so that the cost-effectiveness of retrofit options and other loss-reduction measures can be realistically evaluated.

Responsible Agencies

- Utah Seismic Safety Commission
- Utah Division of Comprehensive Emergency Management/Utah Geological Survey/other data providers
- Utah Division of Risk Management/other users of loss estimates
- Structural Engineers Association of Utah

Resources Needed

- Cost to review methods and determine needs: $30,000.
- Cost to apply University of Utah methods: not available at this time.
- Cost to apply ATC-36 methods: not available at this time.
- Cost to apply FEMA/NIBS methods to first earthquake scenario: $250,000.

STRATEGY: Evaluate the indirect losses associated with earthquakes.

OUTPUT: A study assessing the indirect economic losses from earthquakes including: wage and job loss, rebuilding cost, impacts on insurance and financial institutions, and costs of business interruption and failure.

OUTCOME: Identification of indirect economic impacts, resulting in increased preparedness, more rapid recovery, and wise resource allocation.

Background

An earthquake may only last for thirty seconds, but the indirect effects and recovery can last for months or years. The rate of small business failures following an earthquake is high. Also, financial and insurance institutions will incur costs, including disruption of electronic communications and loan/premium payments. Once the costs are known, institutions and businesses can act accordingly in pre-disaster recovery planning.

Implementation

This strategy would be best implemented using the results of a study to estimate the direct losses from an earthquake (see Strategy 5.1). Economists will then be able to estimate indirect losses from direct losses from various scenario earthquakes in various areas. A team of economists will need to be assembled and funding sought to perform the study.

Responsible Agencies
- Utah Seismic Safety Council
- Utah Division of Comprehensive Emergency Management
- Utah Department of Commerce
- Utah Division of Risk Management

Resources Needed
- Cost for study unknown at this time.

STRATEGY: Conduct lifeline collocation vulnerability studies.

OUTPUT: All lifeline collocation sites in UBC seismic zone 3 are identified; a plan is developed for each one.

OUTCOME: During an earthquake emergency, damaged lifelines in one area will not cripple each other.

Background

In many locations, various lifelines, including pipeline, rail, highway, electric, and communications are located within close proximity of each other, either in defined corridors or at crossings. Seismic damage to one lifeline may easily impact adjacent lifelines. The Federal Emergency Management Agency (FEMA) has funded the study of earthquake-induced failure of the concentrated lifelines at the Beck Street overpass area in Salt Lake City; numerous other similar locations exist along the Wasatch Front.

Implementation

Undertake studies to identify all critical collocation sites within UBC seismic zone 3. Establish a task force of public and private sector lifeline operators to evaluate the potential impacts of their facilities from damage to adjacent lifelines.

Responsible Agencies

Utah Division of Comprehensive Emergency Management
Utah Department of Transportation
Municipal and private utilities, railroads, and pipeline operators

Resources Needed

Cost to identify UBC seismic zone 3 collocation sites and perform screening studies to identify potential risks, using existing methods and data: $100,000.

Cost to perform detailed studies depends on number and complexity of sites and quality of existing data.

GLOSSARY OF TERMS

Aftershock—an earthquake that follows a larger earthquake in the same general area. The number and sizes of aftershocks normally decrease over time, but many are capable of causing injury and damage.

Debris Flow—a muddy slurry of water, soil, rock, and organic material much like wet concrete that flows downslope.

Earthquake—the shaking or vibrating of the ground caused by the sudden release of energy stored in rock beneath the earth's surface.

Epicenter—the point on the surface of the earth directly above the focus or hypocenter (origin) of an earthquake. Point directly above where an earthquake originates.

Fault—a fracture in the earth along which the two sides have been displaced relative to one another.

Focus (hypocenter)—the initial point of rupture of an earthquake below the surface; the point within the earth that is the origin of an earthquake.

GPS—"Global Positioning System" technology, based on satellite signals, that allows the horizontal and vertical position of a point on the earth to be measured with a precision as fine as a centimeter or less using portable receivers.

Hazard—any physical phenomenon that has the potential to produce harm or other undesirable consequences to some person or thing.

Landslide—a general term for any type of downslope movement of rock and soil under the influence of gravity.

Lifelines—utility lines used for the distribution and transmission of oil, gas, water, sewer, and telephone and electrical service.

Liquefaction—loss of strength caused when water-saturated, sandy soils react to vibrations and temporarily act like a liquid.

Magnitude—a quantity characteristic of the total energy released by an earthquake. The Richter Scale is commonly used for Utah earthquakes. It is a logarithmic scale based on the motion that would be measured by a standard (Wood-Anderson) type of seismograph, 100 kilometers (60 miles) from the epicenter.

Non Structural—curtain walls, non-bearing partitions, suspended ceilings, water heaters, filing cabinets, etc.

Normal Fault—dipping fault where the upper block drops down relative to the lower block on the other side. Most Utah faults are normal faults.

Real-Time Monitoring—the recording and processing of seismic data in such a way that immediate post-earthquake information is available within minutes to emergency managers. (Standard earthquake-monitoring schemes typically involve a delay of a half-hour to an hour before seismologists can report the location, size, and extent of an earthquake.)

Retrofit—repair, brace, and strengthen buildings and structures to resist seismic forces.

Risk—the probability that the potential harm or undesirable consequences of a hazard will be realized; the combination of the hazard and the vulnerability.

Seismic—pertaining to an earthquake or earth vibration.

Seismograph—an instrument that records waves generated by an earthquake.

Seismogram—a recording of earthquake waves by a seismograph.

Soil-foundation problems—excessive settlement or heave of soil beneath a building, causing damage to the foundation.

Strong-Motion Instrument—a rugged, low-magnification seismograph designed to record the amplitude, frequency, and duration of strong ground shaking that is potentially damaging to structures.

Unreinforced Masonry—buildings or structures built of brick, concrete, and glass block, hollow clay tiles, or stone that are not reinforced with steel mesh or reinforcing bars.

Zone of Deformation—distortion, slumping and cracking of the ground surface (mainly on the valley side) at or very near the line where a fault breaks or intersects the surface.

Vulnerability—susceptibility to physical injury, harm, or damage.

APPENDIX

The Utah Seismic Safety Advisory Council (USSAC) Members, 1977-1981:

Harvey L. Hutchinson	Chairman; Civil Engineer, Utah Water Conservancy District (Utilities)
Stanley W. Crawley	Vice-Chairman; Professor, Graduate School of Architecture, University of Utah (Architecture)
Genevieve Atwood	Representative, Utah Legislature (Public-at-Large)
Jerold H. Barnes	Director, Salt Lake County Planning Department (Planning)
Winfred O. Carter	Professor, Department of Civil Engineering, Utah State University (Engineering)
William J. Gordon	Geotechnical Engineer, Dames & Moore (Geotechnical Engineering)
Bruce N. Kaliser	Engineering Geologist, Utah Geological Survey (Geology)
Harvey W. Merrell	Utah Association of Counties
Joyce U. Miller	Utah League of Cities and Towns
Donald J. Peck	Public-at-Large
Robert B. Smith	Professor, Department of Geology and Geophysics, University of Utah (Seismology)
Delbert B. Ward	Executive Director; Adjunct Associate Professor, Graduate School of Architecture, University of Utah

The Utah Advisory Council for Intergovernmental Relations, Earthquake Task Force Members, 1989-1991:

Ken Alkema	Director, Utah Division of Environmental Health
M. Lee Allison	Director, Utah Geological Survey
Walter J. Arabasz	Director, University of Utah Seismograph Stations
Kenneth Bullock	Executive Director, Utah League of Cities and Towns
Michael Christensen	Deputy Director, Governor's Office of Planning and Budget
Carl Eriksson	Inspection Services Manager, Salt Lake County
Lorayne M. Frank	Director, Utah Division of Comprehensive Emergency Management

Brent Gardner	Executive Director, Utah Association of Counties
Pat Iannone	Utah Association of Realtors
David L. Johnson	Deputy Director, Utah Department of Administrative Services
Kenneth W. Karren	Structural Engineer, Karren and Associates
Jerrianna Kolby	American Red Cross
Dennis Lifferth	Church of Jesus Christ of Latter-Day Saints
Peter W. McDonough	Senior Operations Engineer, Mountain Fuel Supply Company
Kenneth J. Naylor	American Institute of Architects, Utah Chapter
Ray Nielsen	Representative, Utah Legislature
Craig A. Peterson	Senator, Utah Legislature
Lawrence D. Reaveley	Chairman, Utah Geological Survey Board
Carole Scott	Mayor, Town of Manila
Wilford H. Sommerkorn	Assistant Director, Davis County Planning Department
Neal P. Stowe	Director, Utah Division of Facilities Construction and Management
Richard Thorn	Associated General Contractors
T. Leslie Youd	Professor, Department of Civil Engineering, Brigham Young University

The Utah Earthquake Advisory Board (UEAB) Members, 1991-1994:

Lorayne M. Frank	Chairperson; Director, Utah Division of Comprehensive Emergency Management
M. Lee Allison	Director, Utah Geological Survey
Walter J. Arabasz	Director, University of Utah Seismograph Stations
Kenneth Bullock	Executive Director, Utah League of Cities and Towns
David Curtis	Engineer, Curtis Engineering; Structural Engineers Association of Utah
Frank M. Fuller	Project Coordinator, Utah Division of Facilities Construction & Management

James W. Golden	Assistant Chief Structural Engineer, Utah Department of Transportation
Steven M. Klass	Governor's Office of Planning and Budget, 1991-1993 (Assistant State Planning Coordinator)
John A. Harja	Governor's Office of Planning and Budget, 1993-1994 (Senior Research Analyst)
Suzanne Winters	Governor's Office of Planning and Budget, 1994 (State Science Advisor)
Michael Stransky	American Institute of Architects, Utah Chapter, 1991-1993 (Architect, Stransky and Associates)
Barry Smith	American Institute of Architects, Utah Chapter, 1993-1994 (Architect, Astle-Ericson & Associates)
T. Leslie Youd	Civil Engineer, Brigham Young University; American Society of Civil Engineers, Utah Chapter

The Standing Committees of the UEAB, 1993-1994:

Awareness and Education Standing Committee—M. Lee Allison, Chairperson

Kathy Bledsoe	Parent Teacher Association
Rex Curtis	Retired School Teacher
Steve Lutz	Director, State Fire Academy
Gary Madsen	Associate Professor, Department of Sociology, Utah State University
Hollie Muir	Disaster Education Coordinator, American Red Cross
DeeDee O'Brien	Outreach Coordinator, College of Mines and Earth Sciences, University of Utah
Patrick Reese	Emergency Response, Church of Jesus Christ of Latter-Day Saints
Kay Sadler	MIS Director, West Valley City
Kimm Williams	Public Information Officer, Utah Division of Comprehensive Emergency Management

Engineering and Architecture Standing Committee—David Curtis, Chairperson

Carl Carpenter	Principal Engineer, Provo City Water Resources Department
Scott Ellis	Structural Engineer, Ellis and Associates
Frank M. Fuller	Project Coordinator, Utah Division of Facilities Construction & Management
James W. Golden	Assistant Chief Structural Engineer, Utah Department of Transportation

Peter W. McDonough	Senior Operations Engineer, Mountain Fuel Supply Company
Barry Smith	Architect, Astle-Erickson & Associates
Michael Stransky	Architect, Stransky and Associates

Geoscience Standing Committee—Walter J. Arabasz, Chairperson

M. Lee Allison	Director, Utah Geological Survey
Jeffrey R. Keaton	Senior Engineering Geologist and Vice President, AGRA E and E, Inc.
William R. Lund	Deputy Director, Utah Geological Survey
James C. Pechmann	Research Associate Professor, Department of Geology and Geophysics, University of Utah
Kyle M. Rollins	Assistant Professor, Department of Civil Engineering, Brigham Young University
T. Leslie Youd	Professor, Department of Civil Engineering, Brigham Young University

Response and Recovery Standing Committee—Lorayne M. Frank, Chairperson

Roger Anderson	Assistant Director, Davis County Emergency Services
Roger Forsberg	Manager of Performance Management, Thiokol Corporation
LeGrand Jones	Loss Control Administrator, Utah Department of Transportation
Deborah H. Kim	Emergency Services & Trauma Coordinator, University of Utah Medical Center
Jeff Rylee	Director, Salt Lake City Emergency Services

The Utah Seismic Safety Commission (USSC) Members, 1994:

T. Leslie Youd	Chairperson; Department of Civil Engineering, Brigham Young University; American Society of Civil Engineers, Utah Chapter
Craig A. Peterson	Senator, Utah Legislature
Clark Reber	Representative, Utah Legislature
D. Douglas Bodrero	Commissioner, Utah Department of Public Safety
M. Lee Allison	Director, Utah Geological Survey

Walter J. Arabasz	Director, University of Utah Seismograph Stations
James Bailey	Structural Engineer, Allen & Bailey Engineers; Structural Engineers Association of Utah
Kenneth Bullock	Executive Director, Utah League of Cities and Towns
Lorayne M. Frank	Director, Utah Division of Comprehensive Emergency Management
James W. Golden	Assistant Chief Structural Engineer, Utah Department of Transportation
William E. Juszcak	Project Coordinator, Utah Division of Facilities Construction & Management
Barry Smith	Architect, Astle-Ericson & Associates; American Institute of Architects, Utah Chapter
Suzanne Winters	State Science Advisor, Governor's Office of Planning & Budget

For More Information Contact the Following:

For questions about earthquake preparedness—

The Utah Division of Comprehensive Emergency Management
1110 State Office Building
Salt Lake City, Utah 84114
(801) 538-3400

For questions about geology, faulting, and natural hazards in Utah—

Utah Geological Survey
2363 South Foothill Drive
Salt Lake City, Utah 84109-1497
(801) 467-7970

For questions about earthquake monitoring and research—

University of Utah Seismograph Stations
705 William C. Browning Building
Salt Lake City, Utah 84112-1183
(801) 581-6274

For general geologic information—

U.S. Geological Survey
Earth Science Information Center
2222 W. 2300 South
Salt Lake City, Utah 84119
(801) 975-3742

For emergency services information—

American Red Cross
1391 South Park Street
P.O. Box 6279
Salt Lake City, Utah 84152-6279
(801) 467-7339